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An Electromyographic Study of the Behavior of the Masseter and Temporal Muscles Before, During, and After Orthodontic Treatment: Pt. Ii. Before Treatment and One Week After Placing Separating Wires between the Teeth

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AN ELECTROMYOGRAPHIC STUDY OF THE BEHAVIOR OF THE MASSETER AND TEMPORAL MUSCLES BEFORE, DURING, AND AFTER ORTHODONTIC TREATMENT

Part II

Before Treatment and One Week After Placing Separating Wires Between the Teeth

by

STEVE NOBORU ASAHINO

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LIFE

Steve Noboru Asahino was born in Mahukona, Hawaii, January 21, 1927. He was graduated from the Kohala High School, Honomakau, Hawaii in June, 1944. From August 1945 to April 1948, he served with the United States Army Military Intelligence Corps stationed in Tokyo, Japan. After being honorably discharged from the Army in 1948, he matriculated in the University of Hawaii from whence he was graduated with the degree of Bachelor of Arts, in June 1952. In June 1958, he was graduated from the Loyola University School of Dentistry, Chicago, Illinois with the degree of Doctor of Dental Surgery. He began his graduate studies at Loyola University in June, 1958.

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The findings are composed of photographs of the subject's malocclusion, charts evaluating muscle behavior, and graphs of the duration of chewing stroke.

CHAPTER I

INTRODUCTION

A. Introductory Remarks and Statement of the Problem.

Maintenance and restoration of improved masticatory function are the objectives of orthodontic therapy. The functional behavior of the muscles of the stomatognathic system play an important part in the mechanism of denture dynamics. Since it is believed that the function of the masticatory muscles influences dental environment, the orthodontist attempts to place the teeth in a position that will be harmonious with muscular balance. Muscle behavior is controlled by sensory impulses. Orthodontic forces represent a change in stimuli on the periodontal proprioceptors and it is expected that this may influence the muscle behavior of the stomatognathic system. This investigation was designed to study the effects of these stimuli on the behavior of the masseter and temporal muscles.

Since the placement of orthodontic separating wires between the teeth is the initial phase of treatment in multibanded technic, the nature of muscular behavior to the insertion of these wires, was investigated. Widen (1960) in Part I, and the present investigator began the first phase of a longitudinal study. While Widen studied the effects of likely changes in proprioception on the behavior of the masseter and temporal muscles twenty-four hours after the insertion of separating wires between the teeth, this investigation dealt with the modification in behavior of these muscles after the separating wires re-

mained between the teeth for seven days. This study is Part II of a longitudinal electromyographical investigation designed to study the effects of an orthodontic treatment using light resilient wires and light force elastic upon the behavior of the masticatory muscles.

B. Review of the Related Literature.

1. Electromyographical Background

Electromyography was first introduced to the dental profession by Moyers (1949). He studied the characteristic behavior of muscles in Class II, Division 1 malocclusions and found that none of the cases in this malocclusion group demonstrated normal spike potentials. In 1950, he studied the behavior of the temporal and masseter muscles and ascribed specific functional roles to them.

Numerous electromyographic studies were reported in the literature since Moyers' work on the behavior of the temporal and masseter muscles in normal as well as malocclusion groups. Pruzansky (1952, 1955, 1958), Geltzer (1953), Jarabak (1954, 1956, 1957), Harris and Perry (1954), Perry (1955), Zwemer (1955), Greenfield and Wyke (1956), Greenfield and Timms (1958), and others have contributed substantially their knowledge to the field of electromyography. However, only the report by Greenfield and Timms (1958) dealt with the behavior of the temporal and masseter muscles before, during, and after orthodontic treatment. It was obvious that there was a great need for electromyographic research along this line.

Pruzansky (1952) found that the synergistic behavior of the masseter and temporal muscles changed with the occlusion of the teeth, and that the behavior of these muscles could be correlated with the efficiency of the masticatory apparatus. He described electromyographic patterns of the temporal and masseter muscles in individuals with normal occlusion and malocclusion, and noted the difference in synchrony.

Geltzer (1953) reported the validity of obtaining longitudinal electromyographic data. He said that results were reproducible if the technic was standardized and the variables eliminated as best as possible. He demonstrated three functional components of the temporal muscle, an anterior, middle, and posterior belly. Using known amount of inter-occlusal force, he quantitated the activity of the temporal muscle.

Jarabak (1954) demonstrated the adaptability of the temporal and masseter muscles in various functional situations. He reported that a definite relation existed between occlusion of teeth and the neuromuscular patterns of the temporal and masseter muscles during mastication. An analysis of the myograms was made, and he correlated masticatory and muscular activity.

In subjects with normal occlusion, Jarabak found that the masseter and temporal muscles contracted synchronously on the ipsilateral and contralateral sides. He found that:

> Although there may be a division of labor between the temporal and masseter muscles in normal occlusion, the temporal muscle is capable of doing all of the work, in chewing under certain conditions. It may be logically assumed that one can not ascribe a true function to any given muscle for any

> given time. The function of the muscles is generally predetermined by the status quo of the body in space.

He reported that there was absence of synchronous firing in the temporal and masseter muscles both ipsilaterally and contralaterally in a subject with large interocclusal space (17mm). Reduction of this space with an orthodontic splint re-established synchrony to these muscles and brought the previously electromyographically silent masseter muscle back into action.

In an electromyographic investigation of muscular and temporomandibular joint disturbances due to imbalances in occlusion, Jarabak (1956) found that occlusal interferences

> ... can transmit stimuli through the proprioceptors or the periodontium to establish a pattern of neuromuscular activity which tries to circumvent the occlusal interferences ... Sensory impulses recording these interferences are reflexly transmitted to muscles regulating mandibular movements. These muscles then develop a pattern of activity, sometimes one of spontaneous hyperactivity, to steer the mandible around this point of tooth interference.

Perry and Harris (1954) found that the temporal and masseter muscles reached peak activity asynchronously in Class II, Division 1 malocclusions, and that the preferred side showed less disharmony of activity.

Perry (1955) demonstrated in Class II, Division 1 malocclusion group that no single muscle unit appeared to initiate the chewing cycle in the same patient or within the group. There was very little synchrony of the contracting units. He said:

> In all patients there was an inconsistent multiplicity of amplitude peaks and a 'searching' pattern in the contracting units.

He explained this occurence on the basis of tooth interference during closure to the occlusal position. Harmony and correlation of muscle activity, he wrote, could be attributed to normal cusp and inclined plane relation.

Greenfield and Wyke (1956) attempted to isolate normal and malocclusion groups electromyographically but did not succeed because of inconsistencies in the groups studied. He stressed, however, that in longitudinal studies, maintenance of good head position was imperative in acquiring realiable data.

2. Neuromuscular Mechanism

A brief review of the neuromuscular mechanism is necessary in order to best understand the phenomenon of mastication. The role of proprioceptors in the functional movement and reflex movements of the mandible was shown by Sherrington (1917) and Corbin and Harrison (1940).

Sherrington described the chewing act in the following manner:

> On the mouth's seizing a morsel the mandible, when it has closed, e.g. voluntarily, upon whatever is between the jaws, pressing it against the gums and teeth and hard palate, by so doing, as is clear from observation of the reflex, produces a stimulus which tends reflexly to reopen the jaws. That done the central rebound of the previously reflexly inhibited jaw-closing muscles, or rather their motor neurons, for the inhibition is central, sets in and tends to powerfully reclose the jaws again. The reclosure brings into operation once again the jaw opening stimulus. And so, after being started by a first bite, a rhythmic masticatory reflex tends to keep itself going so long as there is something biteable between the jaws.

Corbin and Harrison (1940) found that alveolar and palatine nerves carried afferent mesencephalic root fibers. These proprioceptive impulses were part of the protective "feed-back" mechanism of the masticatory system and helped to prevent damage to the teeth and gingivae during mastication. These impulses and those passing via the masticatory nerves make up the afferent limbs of the masticatory reflex arcs which coordinate and control movements of mastication.

Szenthagothai (1948) described the monosynaptic pathway involved in the stretch reflex. He reported that the afferent proprioceptive fibers from the masticatory muscles entered the brain stem by way of the motor root of the trigeminal nerve. Here, it made a monosynaptic connection with the motor neurons of the Vth nerve. The cell bodies for these proprioceptive fibers were found in the mesencephalic nucleus of the Vth nerve.

Sicher (1949) compared mastication with walking and emphasized the adaptability of the mechanism. He stated:

> The masticatory movements of the lower jaw are automatic movements which occur under considerable force and under some contact of two rows of teeth. Like other automatic movements, they are characterized by great stability in each individual which, however, does not preclude a considerable adaptability.

He further stated that the masticatory movements vary in details in different individuals and is dependant on the shape and proportion of the jaws of the teeth. Once the pattern of chewing established as an automatic series of movements, their pattern maintained quite persistently. However, he stated:

> ...loss of teeth or changes in their position are followed by a rather rapid adaptation of the movements in order to achieve maximum effect with minimum effort; that is with the least waste of muscular energy.

The function of muscular activity depended on nervous impulses originating in the proprioceptive system. The reflex nature of the masticatory act depended highly on the integrity of these afferent nerve endings. In muscles and tendons, the nerve endings were found in the shape of spindles. These receptors record various states of tension coming from muscles and tendons as the result of muscular activity. In the periodontal tissues, numerous receptor organs can be found with similar function. These afferent endings were considered the first line of "defense" or control against excessive pressures which may injure the periodontium.

3. Histological Background

Tactile sensory receptors of the periodontal membrance were histologically described in the literature by Dependorf (1913), Lewinsky and Stewart (1927), Kadanoff (1936), Van der Sprenkel (1936), Bernick (1957) and Rapp (1957)

Dependorf (1913) described networks of neurofibrils in the periodontal membrane which ended in the cementoblastic region.

Kadanoff (1936) observed that in terminal plexuses of neurofibrils, some had small knob-like swellings. He saw no encapsulated neural endings. Kadanoff did not find endings in the cementoblastic layer in contrast to Dependorf's findings.

Lewinsky and Stewart (1927) described neurofibrils of the periodontal

membrane as separating into fine arborizations or terminal networks. Many of these terminal neurofibrils ended in small rounded bodies. Bernick (1957) corroborated their findings, but in addition, reported long spindle-like nerve endings located mainly in the apical one-third.

Van der Sprenkel (1936) considered the nerve terminals of the tooth capable of regulating by reflexes the motion and course of the chewing act. He postulated:

> The tooth might be regarded as an organ, fitted on the one hand for the function of chewing and on the other by its intradental and extradental nerve endings, which are stimulated by deformation and movement of the tooth, to act as the receptor in the reflex arc for the regulation of the act of mastication.

Rapp (1957) found several types of nerve endings in the periodontal membrane. He reported seeing

(1) large neural trunks that run from the apex of the root to the gingiva;

(2) interweaving fine neurofibrils running apically and gingivally from the alveolar bone;

(3) organized encapsulated neural terminations spread throughout the periodontal membrane;

(4) free nerve endings also spread throughout the periodontal membrane;

(5) neural coils along the surface of the cementum.

That the periodontium has remarkable recuperative power and adaptability to occlusal trauma was demonstrated by Wentz, Jarabak, and Orban (1958) in their histological experiments with monkeys. They found that in induced jiggling of

the premolar tooth with an orthodontic appliance:

> Traumatic tissue changes of the early experiment, completely disappeared within three months and the periodontium appeared normal except for the lengthened periodontal ligament. The widening of the periodontal space and lengthening of the periodontal ligament may be considered as a functional adaptation of the tissues due to changes in the functional requirements.

CHAPTER II

METHODS AND MATERIALS

A. Selection of Subjects

Sixteen patients between 10 and 14 years of age were selected for this study from the Orthodontic Clinic of the Loyola University School of Dentistry. These patients presented with Class I and Class II (Angle) malocclusions which were to be treated with light, resilient wires and light elastic forces.

B. Muscles Studied

The muscles selected for study were the posterior and middle fibers of the right and left temporal muscles and the right and left masseter muscles. These muscles were chosen because of their importance in masticatory function and accessability for the placement of surface electrodes. The middle temporal fibers act as elevators of the mandible. The posterior temporal fibers are concerned with lateral and posterior movements of the mandible. The muscles of the right side were recorded and studied separately from the muscles of the left side.

C. Electromyographic Equipment

The electromyographic equipment consisted of a six channel offner Encephalograph Type A modified for electromyography, a crystograph with six pen

writers, a time base marker with a separate pen attached to the crystograph, a signal generator and microvolt calibrator, and a Faraday cage with an electrode terminal board mounted therein. The amplifiers were set at a gain of 5; the "Hi" and "Lo" condenser switches were set at "In and ".05" respectively to suppress the low frequency of the Encephalograph and bring out the high frequency of the Encephalograph. The paper speed was set at 10 cm. per second the time base marker indicated intervals of 1/10 of a second. The electromyograph was calibrated from 10 to 250 microvolts before and after each experiment. (Figure 1)

D. Sound Equipment

The components of the sound system were a bone conduction microphone (Zenith Hi-Lo, Regent Type), a matching transformer (Shure Model A 86 A), a preamplifier (Heathkit WA-P2), a tape recorder (Wollensak Stereo Modal T-1515), an auxiliary amplifier system (two 12 watt amplifiers), and one channel of the electromyograph and the crystograph. (Figure 2). The bone conduction microphone was placed on the subject's forehead and held in position by a spring-type headband. The microphone was connected in series with the matching transformer and the preamplifier. The output from the preamplifier was sent into the tape recorder and auxiliary amplifiers. Tape recordings were made at 7 and ½ feet per second with a volume level of 5, tone control at "treble" and the monitor switch at "on" position. The preceedings were monitored through the tape recorder as they were recorded to insure proper performance of the exercises. The output from the auxiliary amplifiers entered a channel of the

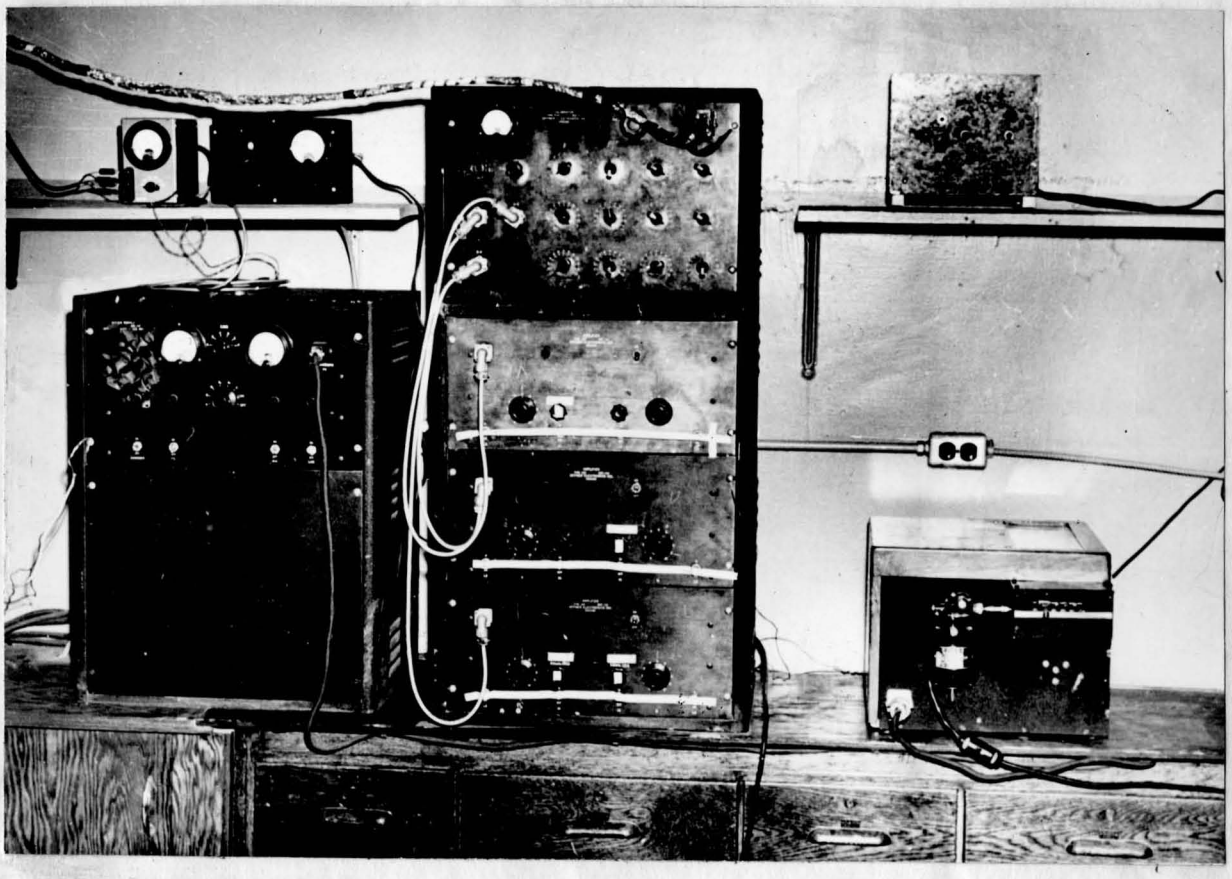


FIGURE 1

ELECTROMYOGRAPHIC EQUIPMENT

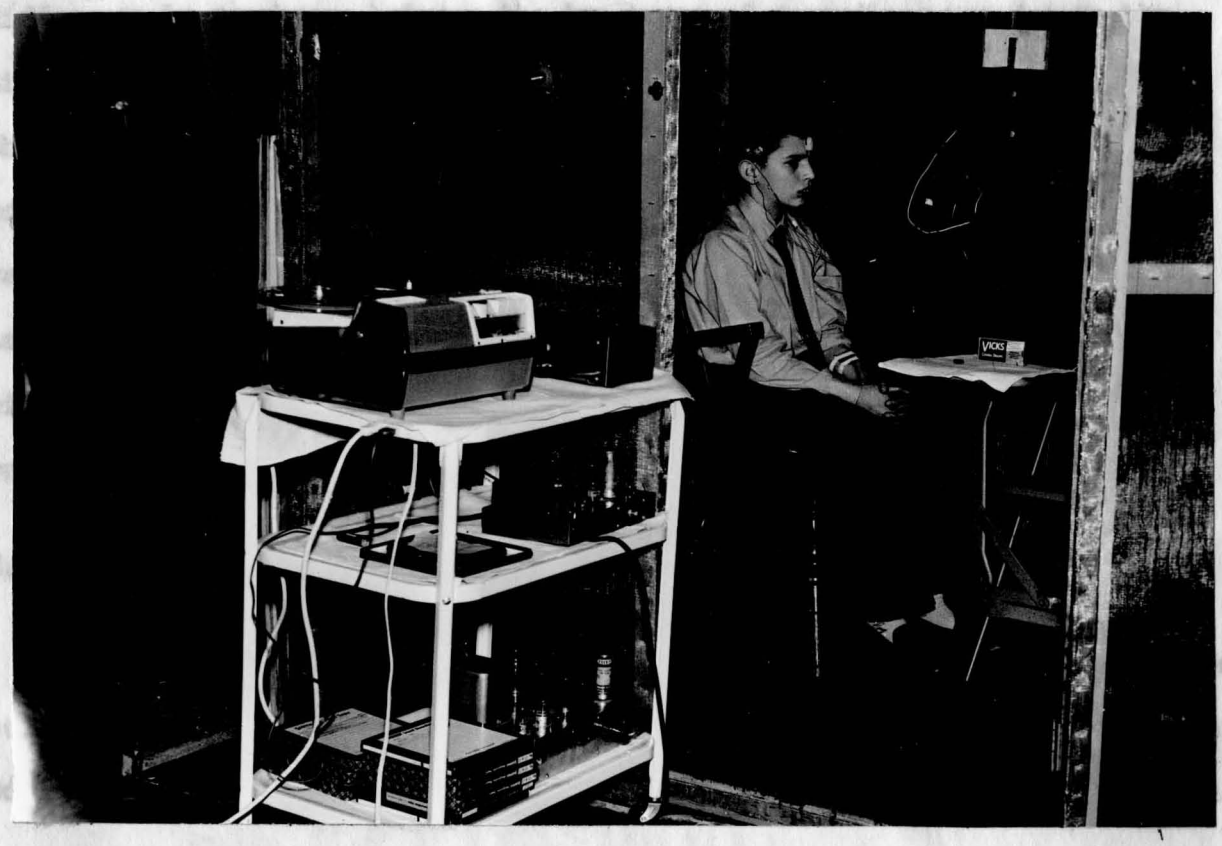


FIGURE 2

SOUND EQUIPMENT

electromyograph set at a gain of 9 and was converted into sound tracings by the crystograph. These sound tracings called "sonograms", were simultaneously recorded with the myograms. The degree of synchrony between the sonograms and the myograms was studied and found to be within 1/100 of a second. This slight difference in synchrony between the two types of recordings was due to the time necessary for the chewing and tapping sounds to travel from the area of the teeth to the forehead, where the microphone was located. The sonograms consisted of a base line and deflections from the base line (spikes) of varying amplitudes, frequencies and durations, which corresponded with the tapping and chewing sounds emitted during the test exercises. The sonograms of tapping were simple, consisting of single spikes, while those of chewing were more complex. (Figures 3 and 4).

E. Chewing Medium

The chewing medium used was Vicks cough drops. Vicks drops were selected because of their uniform size and hardness. Chewing this material yielded sounds easily detected by a bone conduction microphone placed on the forehead.

F. Electrode Placement

Three types of electrodes were used; surface electrodes, a reference electrode, and a ground electrode. Monopolar disk surface electrodes were used because the temporal and masseter muscles lie close to the skin on the side of the head. The absence of underlying superficial or adjacent muscle tissue makes the use of this type of electrode more practical for studying

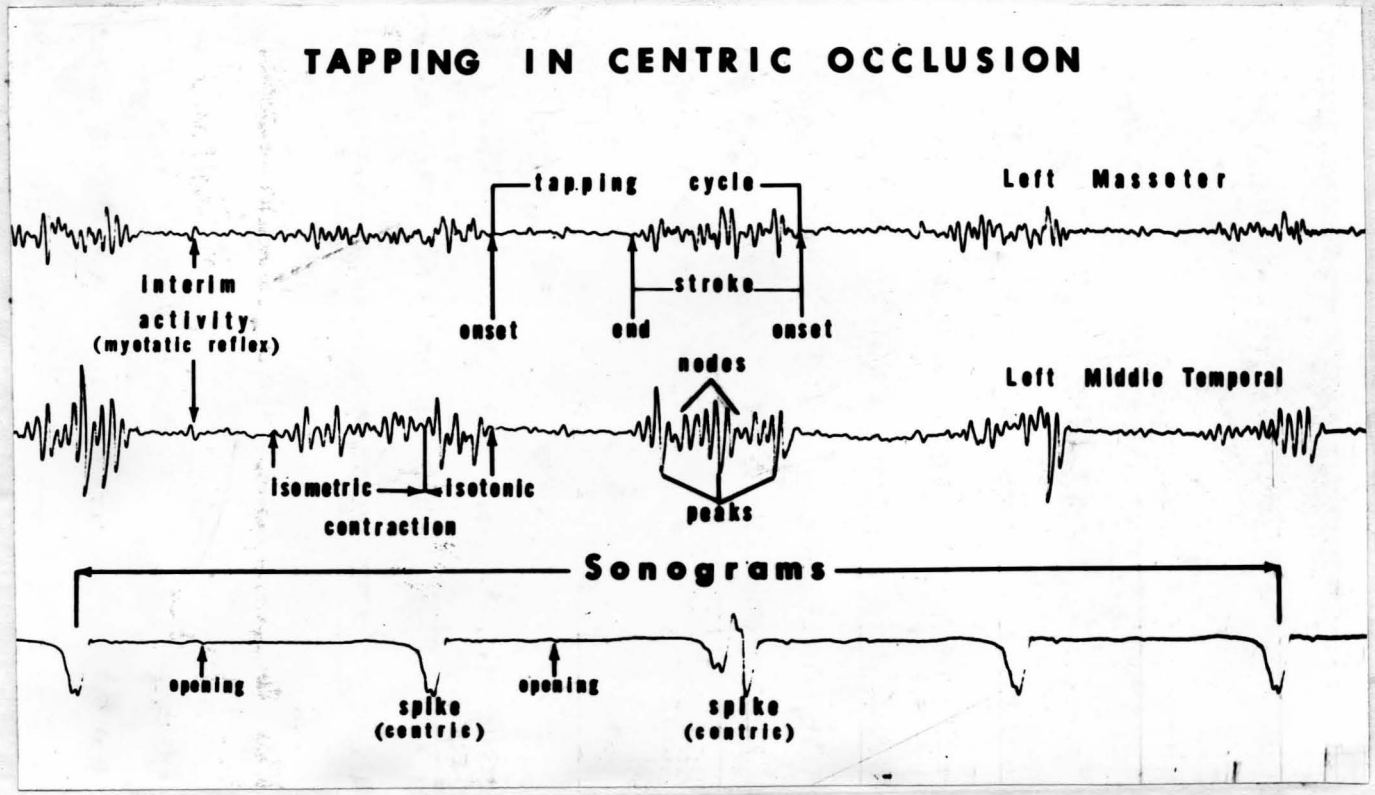

TAPPING IN CENTRIC OCCLUSION
tapping cycle
Left Masseter
interim activity (myotatic reflex)
stroke
onset
end
onset
nodes
Left Middle Temporal
isometric contraction
isotonic
peaks
Sonograms
opening
spike (centric)
opening
spike (centric)

FIGURE 3

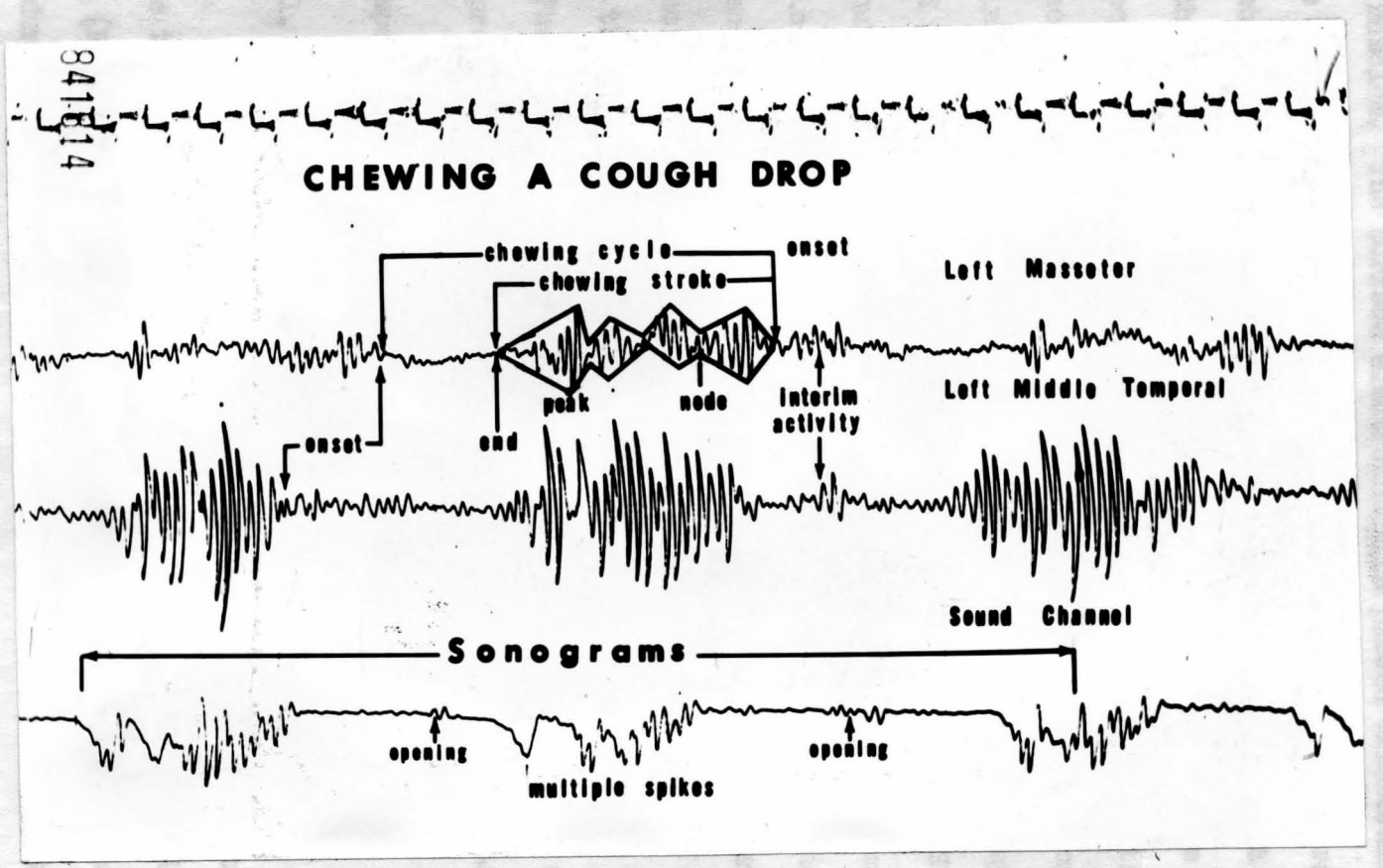

84-1814
CHEWING A COUGH DROP
chewing cycle
onset
chewing stroke
Left Masseter
peak
node
interim activity
Left Middle Temporal
onset
end
Sound Channel
Sonograms
opening
opening
multiple spikes

FIGURE 4

these muscles. The surface electrodes were placed bilaterally on the bellies of the posterior and middle temporal muscles and on the masseter muscle midway between its origin and insertion. To facilitate correct electrode placement the patient was instructed to clench his teeth and then relax, enabling the operator to palpate and select representative areas of the muscles studied. When necessary, the hair was trimmed, exposing an area approximately one-half inch in diameter. The selected areas were cleansed with soap and water, rubbed with acetone and then rubbed with electrode jelly. Skin resistance was thus reduced to 5,000 ohms or less which facilitated greater discrimination in pick up of low amplitude electrical potentials of the muscles. The reference electrode was clipped to the left ear lobe after similarly preparing the skin surface. The ground electrode was attached to the left forearm after the same skin preparation. (Figure 5).

Photographs of each subject showing electrode position were taken to insure proper replacement of electrodes in future experiments.

G. Experimental Procedure

1. Before Orthodontic Treatment - (Experiment #1)

The subject was seated in a Faraday cage, the electrodes connected to the terminal board, and the bone conduction microphone placed on his forehead. (Figure 5) A printed list of instructions was given to him and the procedure explained. The subject was told to recite each item on the list and perform the required exercises. These exercises were (1) "rest", (2) tap teeth together in centric occlusion, (3) chew a cough drop on the right side,

FIGURE 5

ELECTRODE PLACEMENT

(4) chew a cough drop on the left side. Resting was enhanced by instructing the subject to relax, close his eyes, allow his arms to lie passively in his lap, and his feet flat on the floor. When the crystographic pens showed minimum movement, activity at rest was recorded. Tapping was performed ten times, "slowly and hard". At the beginning of the chewing exercises the subject placed the cough drop between the teeth on the designated side and was told to "chew slowly and hard ten times". Duplicate exercises were performed to minimize the experimental error. Tape recordings of all recitations and exercises were made along with the myograms and sonograms. Rest and tapping exercises were recorded unilaterally and the chewing exercises were recorded ipsilaterally

2. Orthodontic Procedure

Separating wires were placed between the teeth to gain space for forming and placing bands around the teeth. The number of separating wires placed varied from subject to subject depending on the malocclusion and the amount of space required. After the placement of separating wires, the subject was told to return seven days later for further electromyographic recordings.

3. Seven Days After Placing Separating Wires Between the Teeth (Experiment - #3)

Recordings were taken in Experiment #3 in the same manner as in Experiment #1 approximately seven days after placing the separating wires. The electrodes were repositioned accurately because the previously prepared areas still showed definite markings. The same instructions were given and complete records were taken as before.

H. Utilisation of Sound Data to Interpret Electromyograms

The data consisted of myograms, sonograms, and tape recordings of the temporal and masseter muscles taken during tapping, chewing, and at rest. The myograms and sonograms taken at rest permitted an evaluation of the base line or minimum activity in the muscle and sound channels. Myograms compared with the sonograms taken during the tapping exercises, showed a correlation between tapping sounds and muscle activity. The sound of teeth meeting in centric occlusion produced a single spike sonogram. By noting the sound spike and its relation to the activity of the myograms, that part of the myogram preceding the spike was identified as the isotonic contraction of the "free stroke", while that part of the myogram succeeding the spike was identified as isometric contraction of the centric occlusion. (Figure 1). Thus, isotonic contractions were distinguished from isometric contractions. This information was then applied to the study of chewing activity. The chewing exercises were selected for two reasons. First the act of chewing was mainly reflex in nature and therefore, relatively free from the influence of both subject and the experimentor. Secondly, chewing the selected medium subjected the teeth and their supporting structures, muscles and joints to stresses which tested their functional ability. The cough drop, selected because of its hard consistency, made chewing difficult and at times impossible. Thus, some of the resulting myograms showed that the masseter and temporal muscles were in "a state of confusion", and a "searching pattern" was recorded having no definite boundaries. One could not tell from looking at these myograms whether or not a chewing

stroke had been completed. Therefore, sound data were resorted to as an interpretative aid. By playing the tape recording of the exercise in question at 7½ feet per second, and then at 3 3/4 feet per second (the slow motion appraisal), the actual sounds of the chewing exercises were scrutinized. The loudness of the sounds identified the chewing strokes. These recorded sounds of the chewing strokes matched the spikes on the sonograms. The sonograms were then related to the myograms which defined the boundaries of the chewing strokes. Thus, the sound data aided the interpretation of the electromyographic data.

I. Selection of Myograms for Study

The myograms from the first three chewing strokes of the right and left side of duplicate exercises were selected for study. Hence, a total of 36 myograms taken from 3 muscles during the first 3 chewing strokes of the 4 chewing exercises of each experiment were analyzed. Those of the succeeding chewing attempts were not selected because as chewing progressed the cough drop became an unmanageable tacky mass.

J. Defining Characteristics of the Myograms

The myograms presented three basic characteristics, amplitude, duration, and form, which were readily identified and studied. Amplitude was studied as a whole and as its parts; high amplitude "peaks", and low amplitude, sustained or transitory. Low amplitude transitory activity bordered by high amplitude activity was called "noding". (Figure 4). Some "nodes" showed amplitude reductions down to base line levels while others showed considerable amplitude.

Sustained low amplitude was prolonged minimum activity devoid of "peaks" and "nodes". Duration of the muscular activity for each chewing stroke was studied as a whole and also divided into two components, onset of activity and end of activity. The rate of increase of amplitude at the onset of activity, and the rate of decrease of amplitude at the end of activity was also noted. Form of the electromyograph was analyzed for frequency of bursts of activity. To demonstrate the form graphically, lines were drawn on the myograms connecting spikes of minimum amplitude with spikes of maximum amplitude. (See Figure 4.) The activity between the myograms of successive chewing strokes, termed "interim activity" was also identified and studied. (Figure 4.)

K. Evaluation of the Electromyographic Data

To gain a knowledge of the behavior of the temporal and masseter muscles within the experimental conditions, the myograms from Experiments #1 and #3 were analyzed and compared. The myograms were studied in the following manner:

Method I - Listing and evaluating their characteristics.
Method II - Evaluating concurrence and similarity of certain characteristics.
Method III - Analyzing the onset of the chewing activity.
Method IV - Measuring the duration of the chewing stroke.

The results of each method of study appear together in chart form for subject in the "Findings".

1. Characteristics of the Myograms - Method I

The following characteristics were grouped and grossly evaluated: bursts, amplitude, duration, noding, sustained low amplitude, rate of onset, rate of ending, and interim activity.

The rating scale used for evaluating all of the characteristics other than bursts (which were counted) was as follows:

xxx = maximum
xx = medium
x = minimum

The results appeared as Chart 1 in the findings. For example, if the amplitude in the myograms of Experiment #1 was high, a rating of xxx appeared opposite AMPLITUDE in the appropriate column of the experiment. If the amplitude of the myograms was moderate, then xx value appeared opposite AMPLITUDE in the appropriate column. If the amplitude was low, then the value of x appears opposite AMPLITUDE under the appropriate column of the experiment.

2. Concurrence and Similarity - Method II

A leeway of 1/40 of a second, equivalent to one half of the small vertically lined dividions of the myogram paper, was allowed to account for the slight difference in alignment of the crystograph pens and for the variation in phase of the tracings.

(a) Evaluation of Concurrence of the Myogram

In order to evaluate the degree of concurrence among the three muscles, their myograms were analyzed for certain characteristics; namely, onset ending, "nodes", and peaks and rated by the following scale and recorded on a tally sheet.

xxx = high degree of concurrence
(3 muscles acting concurrently per chewing stroke)

xx = medium degree of concurrence
(2 muscles acting concurrently per chewing stroke)

x = low degree of concurrence
(used only in rating peaks and "nodes")

0 = no concurrence

- = (see onset and end)

The x signs were added up and given numerical totals which were used in testing concurrence between experiments. These values appear in Chart 2 of FINDINGS.

(b) Evaluation of Similarity of the Myograms

(1) Wave Form

Degree of similarity of wave forms between the masseter, middle temporal, and posterior temporal muscles for each chewing stroke was evaluated in the following manner. If the wave forms of three muscles from one chewing stroke showed a high degree of similarity, a value of xxx was given. If wave forms of two muscles from one chewing stroke resembled each other, then a value of xx was given to this muscle activity. If only parts of the wave forms resembled each other, a value of x was given. When there was no resemblance between wave forms, a value of zero (0) was ascribed. These values were recorded on a tally sheet and the totals for each experiment appear in Chart 2 of FINDINGS.

(2) Interim Activity

In appraising interim activity, a different scale was used. the complex nature of the activity posed a problem in evaluation, which neces-

itated a scale with more latitude to cover the various combinations of its characteristics. The scale used was as follows:

5 = 6x high degree of activity within each muscle
3 = 4x moderate degree of activity
1 = 2x minimum degree of activity
0 = base line activity

The "x" signs were added up and given numerical values on the tally sheet and appear in Chart 2 in FINDINGS.

The identity of the masseter, posterior temporal and middle temporal was maintained throughout this evaluation to determine the similarity of activity between the muscles.

(c) Test for Significance

The data represented by the column totals taken from the concurrence/similarity tally sheet of the experiments were put to the Chi-Square test to determine whether or not the difference in concurrence/similarity between experiments was significant.

3. Analysis of Onset - Method III

The myograms from twelve chewing strokes of each experiment (#1 and #3) were analysed and compared to determine which muscle or combination of muscles, initiated the chewing stroke, These data were presented in chart form and the comparison of onset of activity between experiments #1 and #3 was noted.

4. Duration of the Chewing Stroke - Method IV

The duration of the chewing stroke was evaluated as a percentage of the chewing cycle rather than by direct measurement, because the subjects were instructed to chew slowly. These instructions were necessary because some indivi-

duals chewed so fast that the myograms of the chewing strokes were so close together that they could not be separated from each other. Expressing duration as a percentage value helped to correct this artifact. The percentage value formed histograms which were converted into bar graphs. Comparisons Between Experiments #1 and #3 were then made. (See graph).

L. Amplitude of the Myograms

The amplitude was not quantitated because of varying sensitivity of response of the crystograph pen writers and also because of the variability of the resistance in the tracing pens.

M. Statistical Discipline

This study was basically a qualitative study. Few variables were controlled; the population was heterogenous due to various treatments and malocclusions presented. Therefore, each individual was a separate experimental unit unto himself. The nature of this experiment precluded pooling of data for statistical evaluation.

Three observers gathered and analyzed the data collectively and standardized the method of interpretation. The experimental reliability was determined after each of the observers analyzed the same set of data separately and secretly and submitted their results to a Chi-Square test of significance. The result of these tests showed no statistical significant difference among the observers in evaluating the data at the .05 level of probability. This indicated there was less than 5% error among observers.

Statistical discipline was applied to only one of the four methods used to study the data. The concurrence/similarity data of Experiment #1 and #3 were put to the Chi-Square test and judged for significance at the .05 level of probability for 9 degrees of freedom.

"Chi-Square is the statistical test most generally suitable for determining whether or not an observed frequency or occurrence differs significantly from that expected in accordance with some hypotheses. Symbolically, Chi-Square is defined as:

$$x^2 = \sum \left[\frac{(O - E)^2}{E} \right]$$ where $\sum$ denoted the sum of all values; O, the observed frequency of occurence; and E, the frequency expected in accordance with an hypothesis." (Batson).

CHAPTER III

FINDINGS

The findings were presented by means of charts and a graph with accompanying explanations noting difference between experiments for each of sixteen subjects studied. Photographs of each subject's plaster casts were shown and classified according to Angle's classification of malocclusion and the treatments rendered were stated.

Chart 1.

Comparison of the Characteristics of the Myograms Between Experiments. (Qualitative Data)

The characteristics of the myograms were evaluated as described in Methods and Materials and the findings were represented symbolically (xxx; xx; and x).

Chart 2.

Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The data represented the column totals taken from the tally sheets of each experiment. The Chi-Square test was the statistical method employed to determine whether concurrence or similarity between experiments was significant.

Chart 3.

Comparison of Onset of Activity of the Masseter, Middle and Posterior Temporal Muscles Between Experiments.

The analysis of onset chart showed the number of times each muscle or combination of muscles initiated the chewing stroke.

Bar Graph

Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke expressed as percentage values, was plotted as histograms and converted into bar graphs.

FINDINGS

Subject #1 (L.C.) Age: 14 years.

Angle Classification of Malocclusion: Class I

Treatment: Separating wires were placed between all teeth except the upper anteriors.

Subject #1 (L.C.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	1 to 2	2 to 5	x
Amplitude	xx	xxx	x
Duration	x	xx	x
Noding	x	xx	x
Sustained low amp.	0	0	0
Rate of onset	xxx	xxx	0
Rate of ending	xxx	xxx	0
Interim activity	x	xx	x

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

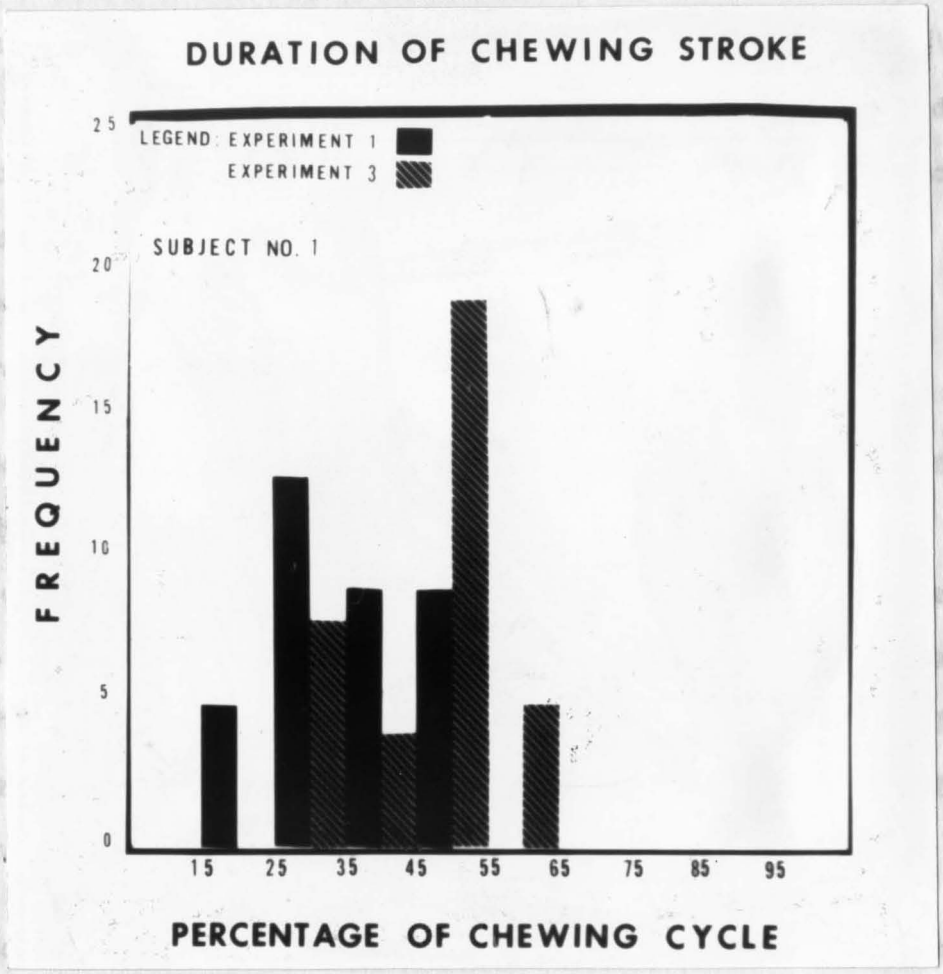
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	23	30	34	34	10	10	11	2	2	4
Exp. 3	32	33	29	32	7	12	12	10	1	9

Chi Square = 6.2197
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
1	Masseter first	2
0	Masseter and middle temporal first	0
0	Masseter and posterior temporal first	1
0	Middle temporal first	0
0	Middle and posterior temporal first	2
1	Posterior temporal first	0
10	All together (synchronous)	7
12	Total number of chewing strokes	12



FINDINGS - Subject #1 (L.C.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments.

Experiment #1 presented myograms of 1 to 2 bursts, moderate amplitude, short duration, little noding, no sustained low amplitude activity, rapid rate of onset and ending, and minimal interim activity.

The myograms of Experiment #3 compared to Experiment #1, showed slight increase in number of bursts, amplitude, and duration; fairly distinct noding, and some increase in interim activity. The other characteristics of the myogram showed no apparent change. This means that the behavior of the masseter and temporal muscles was only slightly altered.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 6.2197. Statistically, this means that there was no significant difference between concurrence or similarity in both experiments at the 95% confidence level. Thus, little change was found in the behavior of the muscles studied.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle, Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 was found to be highly synchronous with all muscles studied initiating the chewing stroke (10 out of 12) majority of the times. Some degree of synchrony persisted in Experiment #3 with all of

the muscles acting together 7 out of 12 times. We may conclude that no appreciable difference in the over-all onset of activity of the muscles could be noted. Some evidence of synchronous behavior was seen in all muscles studied.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 15-55% of the chewing cycle, with the greatest frequency occurring at the 25-35 percentile. In Experiment #3 however, the duration of the chewing stroke ranged from 25-65% of the chewing cycle, with the greatest frequency occurring at the 45-55 percentile. This meant that the subject exercised some caution during the chewing of the Vicks cough drop.

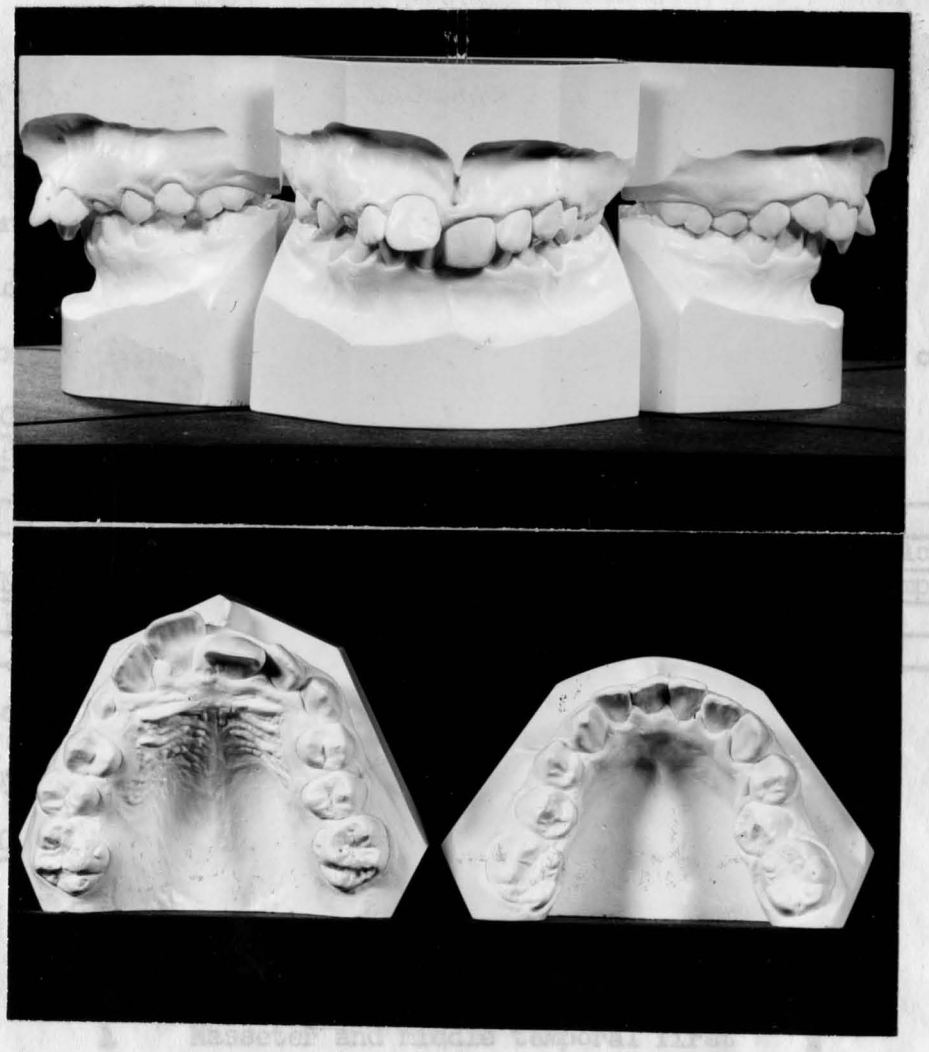
Summary and Conclusion:

The placement of separating wires between the teeth for seven days effected only a slight change in the behavior of the neuromuscular mechanism. Subject #1 showed a measure of adaptability to orthodontic forces.

Subject #2 (E.G.) Age: 11 years.

Angle Classification of Malocclusion: Class II, Division I.

Treatment: Separating wires were placed between all teeth except the upper anteriors.



Subject #2 (B.G.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	4 to 6	4 to 6	0
Amplitude	xx	xx	0
Duration	xxx	xxx	0
Noding	xxx	xxx	0
Sustained low amp.	0	x	x
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	xxx	x	xx

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

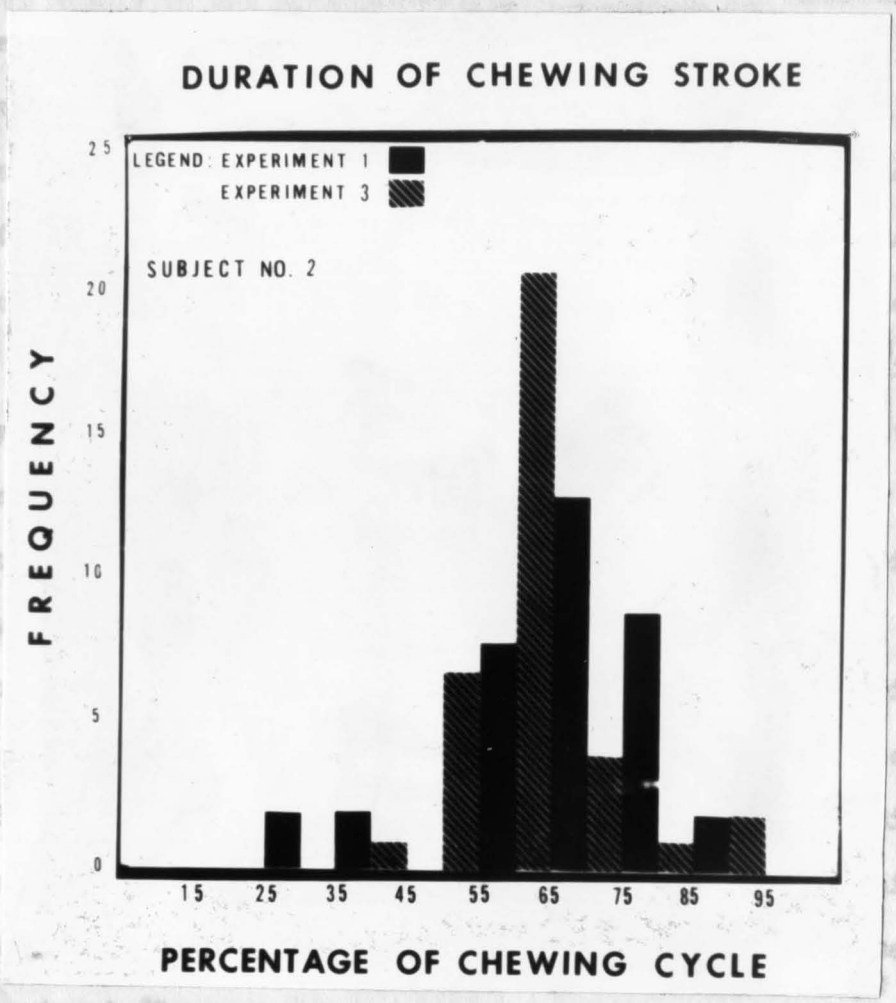
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	27	26	26	26	11	12	10	21	19	19
Exp. 3	29	29	24	25	10	10	8	4	1	1

Chi Square = 36.0569
Degree of Freedom = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
4	Masseter first	6
1	Masseter and middle temporal first	2
1	Masseter and posterior temporal first	0
0	Middle temporal first	0
0	Middle and posterior temporal first	1
0	Posterior temporal first	0
6	All together (synchronous)	3
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 2
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #2 (E.G.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 4 to 6 bursts, moderate amplitude, long duration, distinct noding, no sustained low amplitude activity, moderate rate of onset and ending, and maximal interim activity.

The myograms of Experiment #3 as compared with Experiment #1, showed no appreciable change in the number of bursts, amplitude, duration, noding, and the rate of onset and ending of activity. This means that the behavior of the masseter and temporal muscles remained unaffected with the insertion of separating wires between the teeth. However, a marked change was found in the interim activity, and a slight change in the sustained low amplitude activity. This may be attributed to psychogenic factors.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 34.0567. Statistically, this means that there was a significant difference between concurrence or similarity in both experiments at the 95% confidence level. A substantial decrease in interim activity was perhaps due to lessened apprehension in Experiment #3.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 was mainly synchronous, with all

of the muscles initiating the chewing stroke 6 out of 12 times. The masseter muscle initiated the activity 4 out of 12 times and combination of muscles started the activity the rest of the time. In Experiment #3, there was less synchrony of onset (3 out of 12 chewing strokes), but a predominating role of the masseter muscle (6 out of 12 times), in initiating the chewing cycle. This means that onset of activity of the chewing stroke was variable.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 25-95% of the chewing cycle. The greatest frequency occurred at the 65-75 percentile. The duration in Experiment #3 however, ranged from 35-95% of the chewing cycle, with the greatest frequency of occurrence at the 55-65 percentile.

Summary and Conclusion:

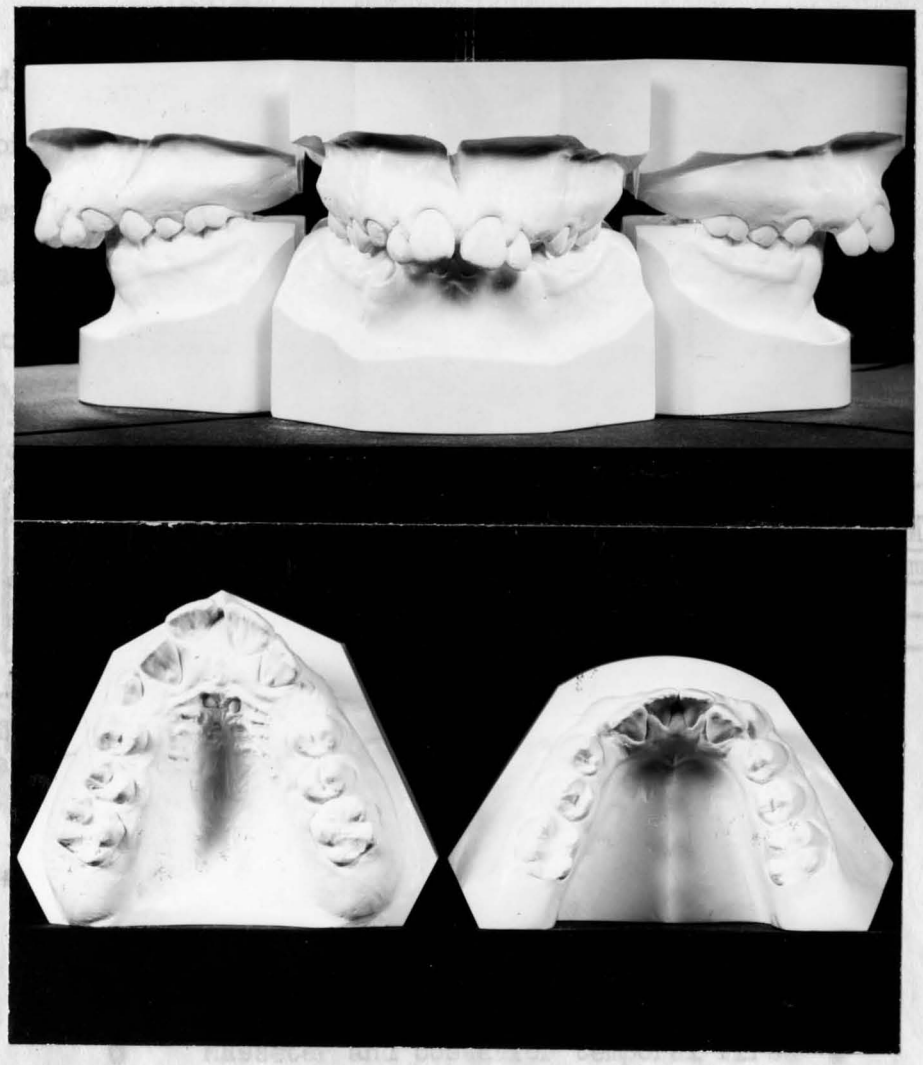
There was some measure of adaptability of the neuromuscular mechanism to orthodontic forces in Subject #2.

FINDINGS

Subject #3 (H.H.) Age: 11 years

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between all teeth except the upper anteriors.



THE BEHAVIOR OF THE MASSETER AND TEMPORAL MUSCLES

Subject #3 (R.H.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	1 to 3	3 to 6	x
Amplitude	xx	xxx	x
Duration	x	xx	x
Noding	x	xx	x
Sustained low amp.	Left Masseter	Left Masseter	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	xx	xx	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

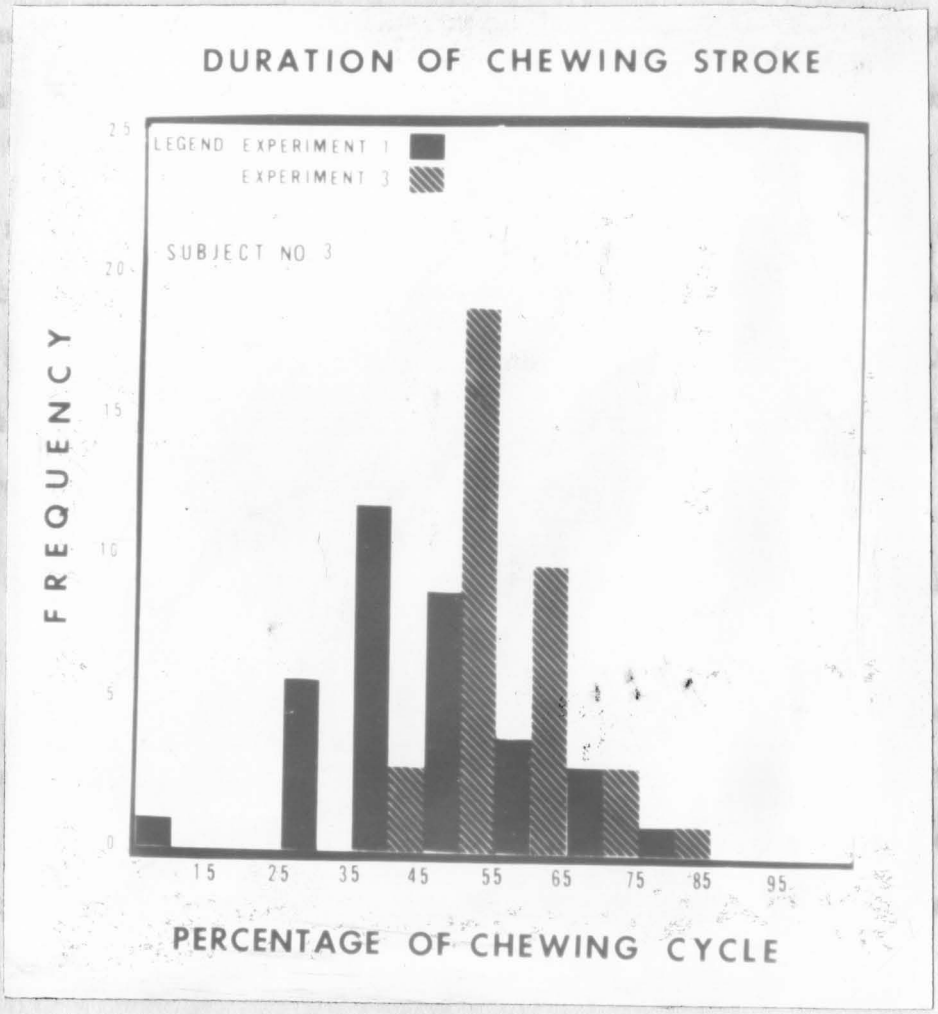
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	26	27	29	28	6	10	10	12	7	15
Exp. 3	31	32	28	31	10	9	12	7	4	8

Chi Square = 4.[illegible]
Degree of Freedom = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
3	Masseter first	3
0	Masseter and middle temporal first	1
0	Masseter and posterior temporal first	0
0	Middle temporal first	0
1	Middle and posterior temporal first	3
3	Posterior temporal first	0
5	All together (synchronous)	5
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO 3
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #3 (R.H.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 1 to 3 bursts, low to moderate amplitude, short duration, indistinct noding, some sustained low amplitude activity, moderate rate of onset and ending, and a moderate degree of interim activity.

The myograms of Experiment #3 as compared with Experiment #1, showed a moderate increase in number of bursts (3-6), increased amplitude, longer duration, and more distinct noding. Other characteristics remained unaltered. This means that the muscle behavior was moderately affected after orthodontic forces were applied for seven days.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 4,003. Statistically, this means that there was no significant difference between experiments at the 95% confidence level. In other words, there was no difference in the subject's ability to chew.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 varied from 3 out of 12 in the

masseter, and 3 out of 12 in the posterior temporal, to 5 out of 12 times in the combination of muscles. No appreciable difference was noted in Experiment #3. Thus, onset of activity remained variable.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 5-85% of the chewing cycle, with the greatest frequency occurring at the 35-45 percentile. In Experiment #3 however, the duration of activity ranged from 35-85% of the chewing cycle, with the greatest frequency occurring at the 45-55 percentile.

This subject showed a moderate amount of disturbance in the neuromuscular mechanism.

Summary and Conclusion:

The placement of separating wires between the teeth for seven days in Subject #3 effected only a moderate degree of change in neuromuscular behavior of the stomatognathic system.

FINDINGS

Subject #4 (M.K.) Age: 10 Years.

Angle Classification of Malocclusion: Class II

Treatment: Separating wires were placed between all teeth except lower cuspids and laterals, and upper right cuspid and its adjacent teeth.

Subject #4 (M.K.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	1 to 3	3 to 5	x
Amplitude	xx	xx	0
Duration	x	x	0
Noding	xx	xx	0
Sustained low amp.	(R.Mass. and P.T. muscles)	(R. Mass. and P.T. muscles)	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	x	x	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

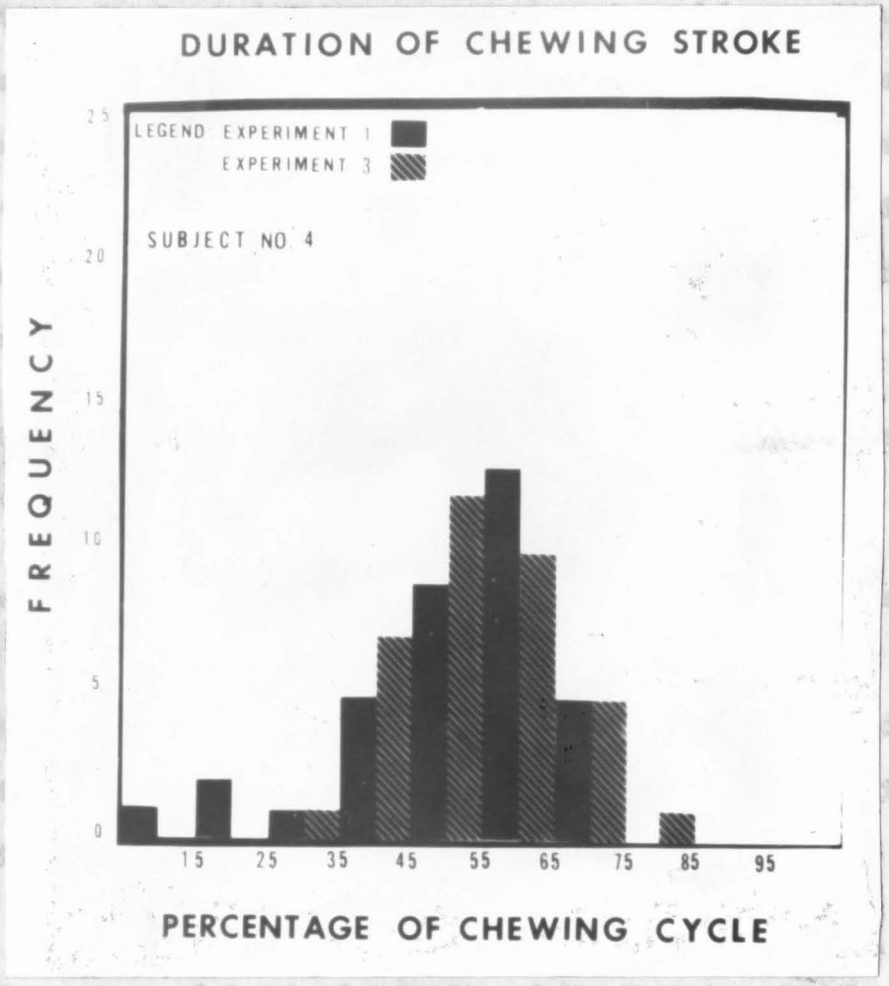
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	26	29	27	32	11	12	12	9	8	9
Exp. 3	29	27	31	31	8	10	9	18	9	10

Chi Square = 3.5424
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
6	Masseter first	4
1	Masseter and middle temporal first	0
0	Masseter and posterior temporal first	0
0	Middle temporal first	1
0	Middle and posterior temporal first	0
0	Posterior temporal first	0
5	All together (synchronous)	7
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 4
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #4 (M.K.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 1 to 3 bursts, moderate amplitude, short duration, fairly distinct noding, some sustained low amplitude activity, moderate rate of onset and ending, and minimum degree of interim activity.

The myograms of Experiment #3 compared with that of Experiment #1, showed a slight increase in the number of bursts, (3 to 5). The remainder of the characteristics apparently remained unchanged. This means that adaptation of the neuromuscular mechanism was virtually complete.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 3.5424. Statistically, this means that there was no significant difference in the characteristics of the myograms between experiments at the 95% confidence level. This again means that the behavior pattern of the muscles remained unchanged.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity of Experiment 1 showed that the masseter muscle initiated the chewing stroke 6 out of 12 times, while the combinations of muscles acted synchronously 5 out of 12 times. In Experiment #3, all the

muscles under study initiated the activity of the chewing stroke in unison, 7 out of 12 times. This means that there was greater synchrony of onset in the latter experiment, and chewing ability remained unchanged.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 5-75% of the chewing cycle with the greatest frequency occurring at the 55-65 percentile. In Experiment #3 however, the duration of activity varied from 25-85% of the chewing cycle, with the greatest frequency occurring at the 45-55 percentile. A high degree of correlation of muscular activity was found in both experiments in this duration graph.

Summary and Conclusion:

Subject #4 showed a good measure of adaptability of the neuromuscular mechanism to orthodontic forces.

Subject #5 (M.M.) Age: 11 Years.

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between the teeth in the lower buccal segments and between the upper left lateral, cuspid and first premolar teeth.

Subject #5 (M.Mc)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	2 to 3	3 to 4	x - 0
Amplitude	x	x	0
Duration	x	x	0
Noding	xx	xx	0
Sustained low amp.	Masseters	Masseters	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	x	x	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

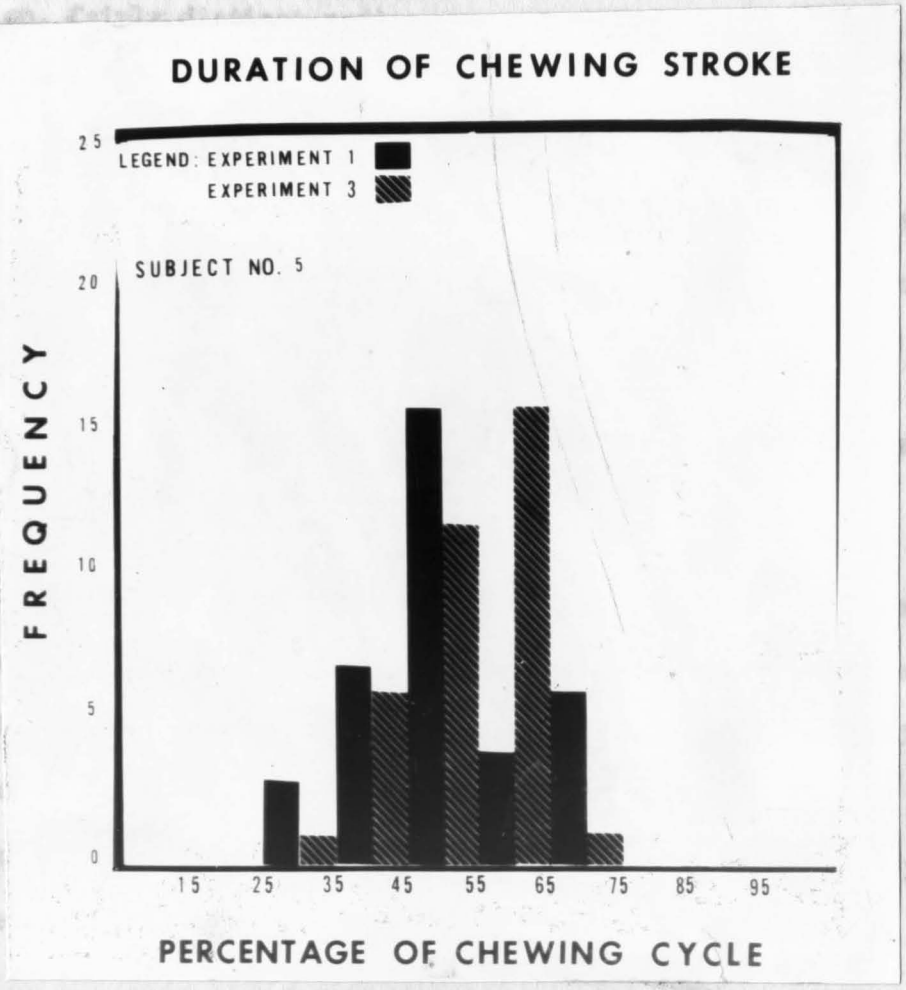
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	23	27	27	30	5	11	11	19	13	13
Exp. 3	29	28	25	29	6	12	12	16	3	8

Chi Square = 6.0137
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
6	Masseter first	3
0	Masseter and middle temporal first	0
0	Masseter and posterior temporal first	0
0	Middle temporal first	0
0	Middle and posterior temporal first	3
1	Posterior temporal first	3
5	All together (synchronous)	3
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 5
FREQUENCY
0
5
10
15
20
25
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #5 (M. Mc)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 2 to 3 bursts, low amplitude and short duration, fairly distinct noding, some sustained low amplitude activity, moderate rate of onset and ending, and minimal interim activity.

The myograms of Experiment #3 compared with that of Experiment #1, showed changes in number of bursts (3-4) only. The remaining characteristics presented no apparent changes. Evidently a certain degree of adaptation to changes in the periodontium may have occurred.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 6.0837. Statistically, this means that there was no significant difference between experiments at the 95% confidence level.

Conclusion: There was no apparent difference in the behavioral patterns of the muscles studied.

Chart 3. Comparison of the Onset of Activity of the Masseter, and Middle and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that the masseter muscle initiated the chewing cycle 6 out of 12 times. The muscles acted in combination

synchronously 5 out of 12 times. The onset of activity in Experiment #3 on the other hand, was variable with no definite rule as to which muscle acted first to initiate the chewing stroke at a given time.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 25-75% of the chewing cycle, with the greatest frequency occurring at the 45-55 percentile. In Experiment #3, the duration of activity ranged from 25-75% of the chewing cycle with the greatest frequency occurring at the 55-65 percentile. This showed that there was a minimal disturbance in the chewing ability of this subject.

Summary and Conclusion:

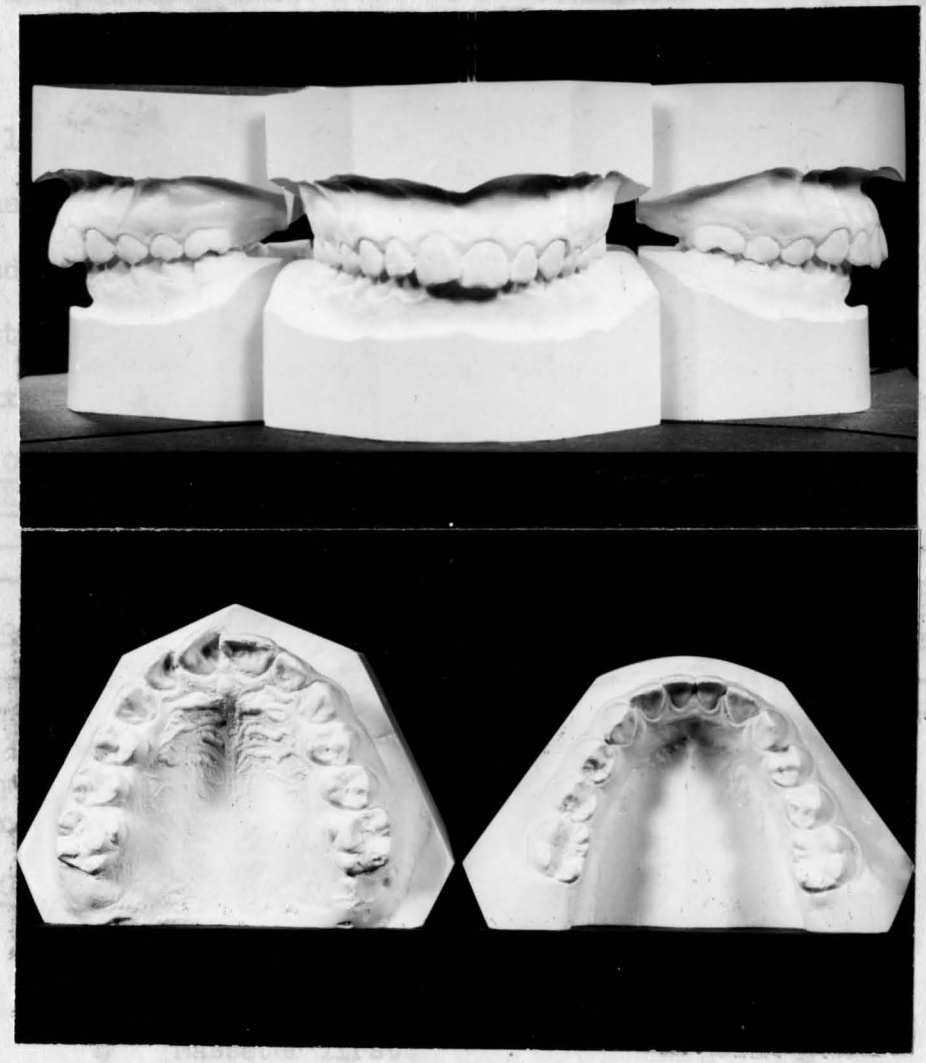
In general, this subject showed no apparent change in his neuromuscular pattern of behavior. He had probably adapted to any changes which may have occurred in the periodontium due to orthodontic forces.

FINDINGS

Subject #6 (K.M.) Age: 13 years

Angle Classification of Malocclusion: Class II

Treatment: Separating wires were placed between all the teeth.



Subject #6 (K.Mo)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	3 to 6	3 to 6	0
Amplitude	xx	xx	0
Duration	xx	xx	0
Noding	xxx	xxx	0
Sustained low amp.	(Left masseters)	(Left Masseters)	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	xxx	xxx	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

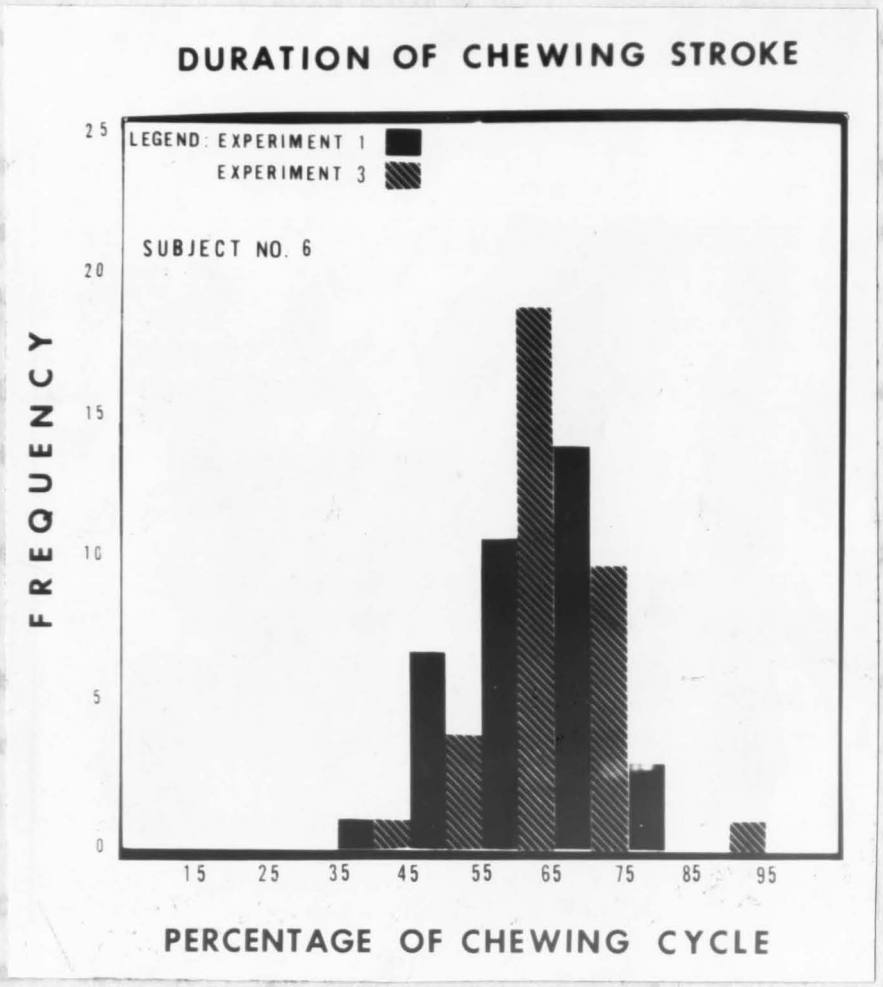
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	28	30	27	28	8	9	11	29	22	26
Exp. 3	23	32	25	30	6	13	12	18	22	22

Chi Square = 1.4668
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
8	Masseter first	3
0	Masseter and middle temporal first	1
0	Masseter and posterior temporal first	2
0	Middle temporal first	1
1	Middle and posterior temporal first	3
0	Posterior temporal first	0
3	All together (synchronous)	2
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 6
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #6 (K. Mc)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 3 to 6 bursts, moderate amplitude, moderate duration, distinct noding, some sustained low amplitude activity, moderate rate of onset and ending, and maximal interim activity.

The myograms of Experiment #3 as compared to that of Experiment #1, showed absolutely no difference. This may be interpreted as total adaptability of the neuromuscular mechanism to orthodontic forces.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 1.4668. This means that statistically, there was no significant difference between experiments at the 95% confidence level. Again, this was a definite measure of adaptability of the neuromuscular mechanism.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that the masseter muscle initiated the chewing stroke, 8 out of 12 times; 3 out of 12 times, the onset was synchronous. In Experiment #3, the onset of activity was variable with no outstanding change.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 35-85% of the chewing cycle with the greatest frequency occurring at the 65-75 percentile. In Experiment #3 however, the duration of the chewing stroke ranged from 35-95% of the chewing cycle, with the greatest frequency occurring at the 55-65 percentile. The graph shows that this subject had no apparent disturbance in his neuromuscular mechenism.

Summary and Conclusion:

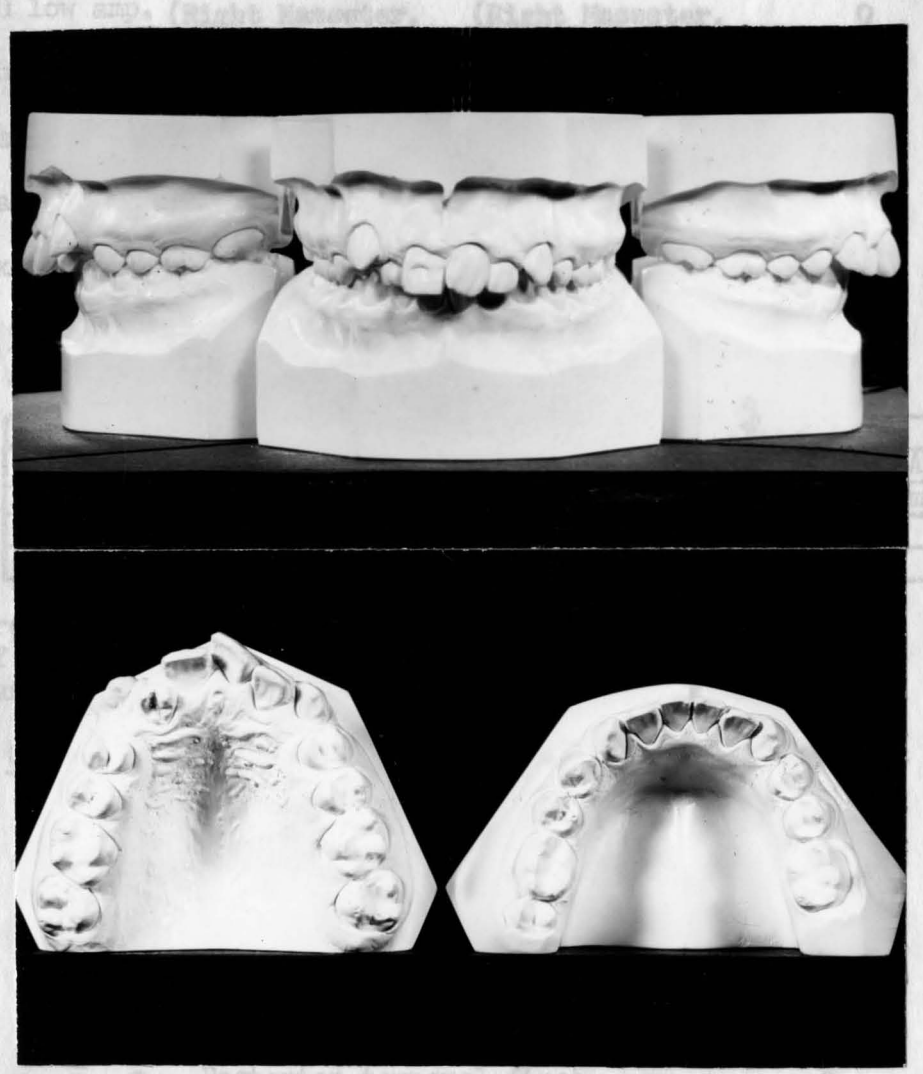
Subject #6 showed evidence of complete adaptability of the neuromuscular mechanism to orthodontic forces.

FINDINGS

Subject #7 (J.N.) Age: 13 years

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between all teeth except the upper anteriors.



Subject #7 (J.M.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	1 to 3; Multi-bursts in first chew.	Multi-bursts	x
Amplitude	xxx	xxx	0
Duration	xx	xx	0
Noding	xx	xx	0
Sustained low amp.	(Right Masseter, first chew)	(Right Masseter, first chew)	0
Rate of onset	xx	xx	0
Rate of ending	xxx	xx	x
Interim activity	(xx, except R.Mass., and P.T. xxx)	x	x

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

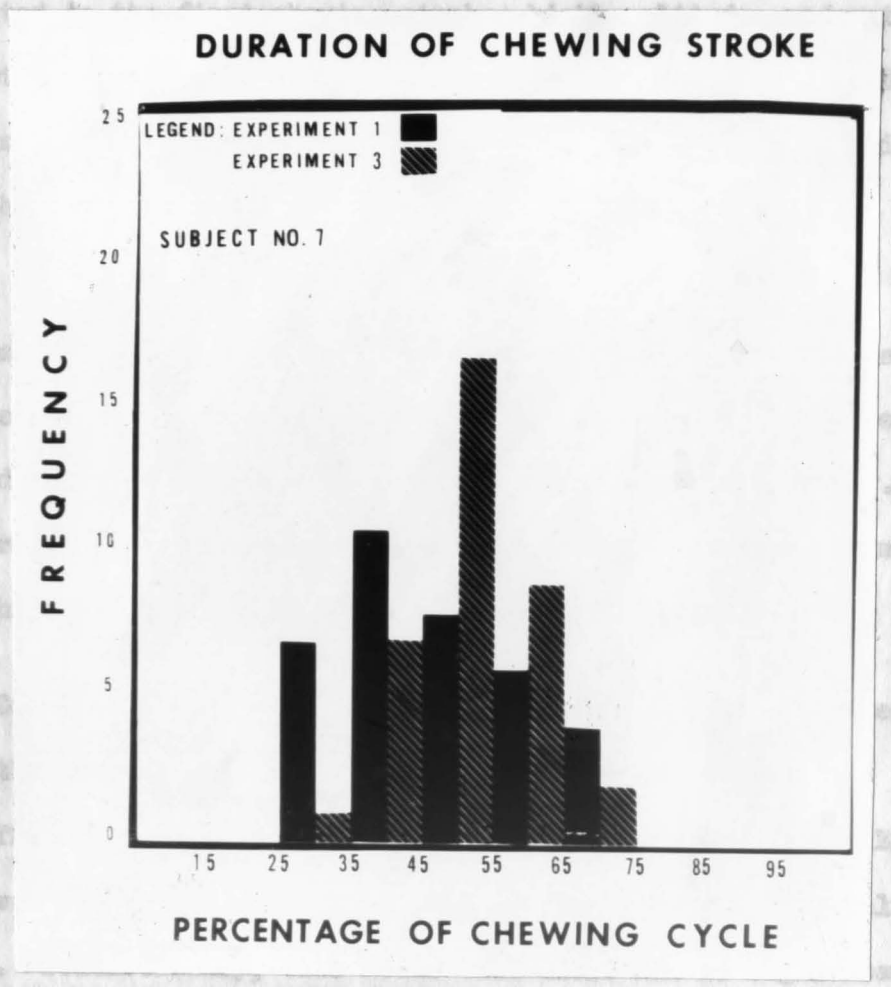
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	26	27	31	28	6	11	12	24	16	19
Exp. 3	32	32	29	27	6	11	12	13	12	13

Chi Square = 6.4412
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
3	Masseter first	5
2	Masseter and middle temporal first	0
0	Masseter and posterior temporal first	0
0	Middle temporal first	0
0	Middle and posterior temporal first	1
0	Posterior temporal first	0
7	All together (synchronous)	6
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 7
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #7 (J.M.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 1 to 3 bursts with multi-burst patterns limited to the first chewing stroke; high amplitude, moderate duration, fairly distinct noding, some sustained low amplitude activity, moderate rate of onset and rapid rate of ending, moderate degree of interim activity except in the right masseter and posterio temporal muscles, where it was found to be maximal.

The myogram of Experiment #3 as compared to that of Experiment #1 showed moderate degree of changes in the number of bursts, a slight decline in the rate of ending and a slight overall reduction of interim activity. The rest of the characteristics listed showed no apparent differences. Overall, this subject exhibited only slight change in his neuromuscular pattern of behavior.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 6.4412. Statistically, this means that there was no significant difference between experiments at the 95% confidence level. A relative decrease in interim activity found in Experiment #3 could be due to lessened apprehension and other psychogenic factors. Otherwise, there was no apparent change in the behavior of the muscles studied.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that the masseter muscle initiated the chewing stroke 3 out of 12 times, the middle temporal muscle started first 2 out of 12 times, and all muscles acted synchronously in intiating the stroke, 7 out of 12 times.

In Experiment #3, the masseter muscle exhibited early onset 5 out of 12 times and there was still a great deal of synchrony of onset with the combination of muscles initiating activity 6 out of 12 times. A moderate degree of synchrony was exhibited.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 25-75% of the chewing cycle, with the greatest frequency occurring at the 35-45 percentile. In Experiment #3 however, the duration of the chewing stroke ranged from 25-75% of the chewing cycle, with the greatest frequency of occurrence at the 45-55 percentile. There was an apparent shift to the right (increase in duration of the chewing strokes) which means that the subject had some difficulty in chewing the Vicks cough drop.

Summary and Conclusion:

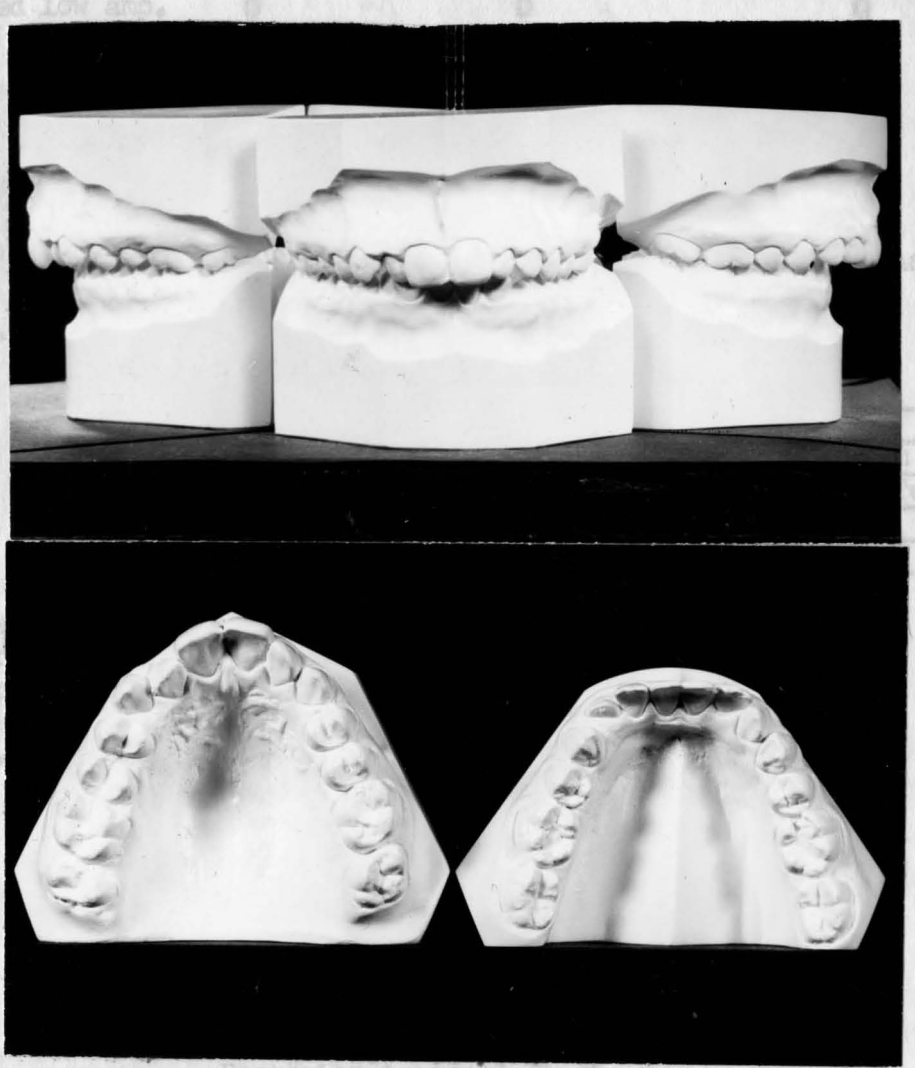
Subject #7 showed a moderate degree of disturbance in the neuromuscular mechanism. Adaptability to orthodontic forces from the tightening of brass separating wires between the teeth, was therefore, considered to be moderate.

FINDINGS

Subject #8 (L.P.) Age: 12 years

Angle Classification of Malocclusion: Class II

Treatment: Separating wires were placed between all the teeth except the lower left cuspid and its adjacent teeth.



Subject #8 (L.P.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	2 to 6	2 to 6	0
Amplitude	xxx	xxx	0
Duration	x	x	0
Noding	xxx	xxx	0
Sustained low amp.	0	0	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	(xxx (esp. Mass.)	xxx	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

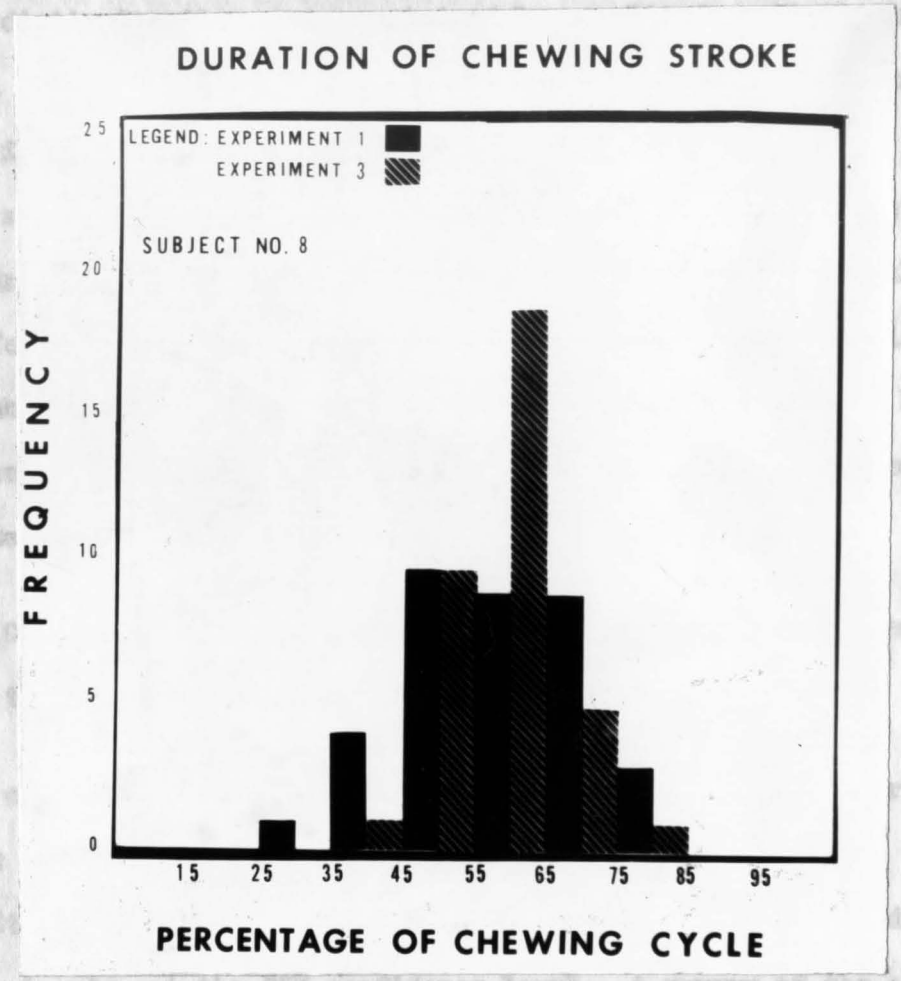
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	29	28	24	25	7	10	8	33	8	9
Exp. 3	32	32	25	31	11	31	11	23	7	5

Chi Square = 3.4777
Degree of Freedon = 9
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
6	Masseter first	5
0	Masseter and middle temporal first	0
0	Masseter and posterior temporal first	1
0	Middle temporal first	0
2	Middle and posterior temporal first	3
0	Posterior temporal first	0
4	All together (synchronous)	3
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 8
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #8 (L.P.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 2 to 6 bursts, high amplitude, short duration, distinct noding, some sustained low amplitude activity in the middle temporals, moderate rate of onset and ending, and maximal interim activity particularly in the masseter muscle.

The myograms of Experiment #3 compared with that of Experiment #1, showed no apparent difference between experiments, except for a slightly depressed activity found in the masseter muscle. The rest of the characteristics showed no noticeable change. This means that whatever changes which may have occurred earlier, seven days later, no apparent changes were noted in the behavior of the masseter and temporal muscles.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 3.4777. Statistically, this means that there was no significant difference between experiments, at the 95% confidence level. A survey of the chart showed that there was no appreciable difference in concurrence or similarity in both experiments.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

In Experiment #1, the masseter muscle starting first 6 out of 12 times, played the dominant role in initiating the chewing stroke. The masseter muscle also acted synchronously with the middle and posterior temporal muscles (4 out of 12 times) to initiate the chewing stroke. There was no pronounced change in the onset of activity in Experiment #3. This shows that no single muscle will initiate the chewing stroke all of the time.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 25-85% of the chewing cycle with the greatest frequency of occurrence between 45-65 percentile. In Experiment #3, the duration ranged from 35-85% of the chewing cycle with the greatest frequency at the 55-65 percentile. There was an increased consistency in this subject's duration of the chewing strokes. Again it was a measure of adaptability to altered periodontal proprioception due to orthodontic forces.

Summary and Conclusion:

Subject #8 showed no apparent change in the behavior of the masseter and temporal muscles. There was a good measure of adaptability of the neuromuscular mechanism.

FINDINGS

Subject #9 (C.R.) Age: 10 years.

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between all teeth except the upper anteriors.

THE BEHAVIOR OF THE MASSETER AND TEMPORAL MUSCLES

Subject #2 (C.R.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	Multiple;(6-8)	Multiple (6-8)	0
Amplitude	xx, Temporal; x, Masseters.	xxx, Temporal; xx, Masseters.	x
Duration	xx	xx	0
Noding	xxx	xxx	0
Sustained low amp.	x, Masseters	0	x
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	x	x	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

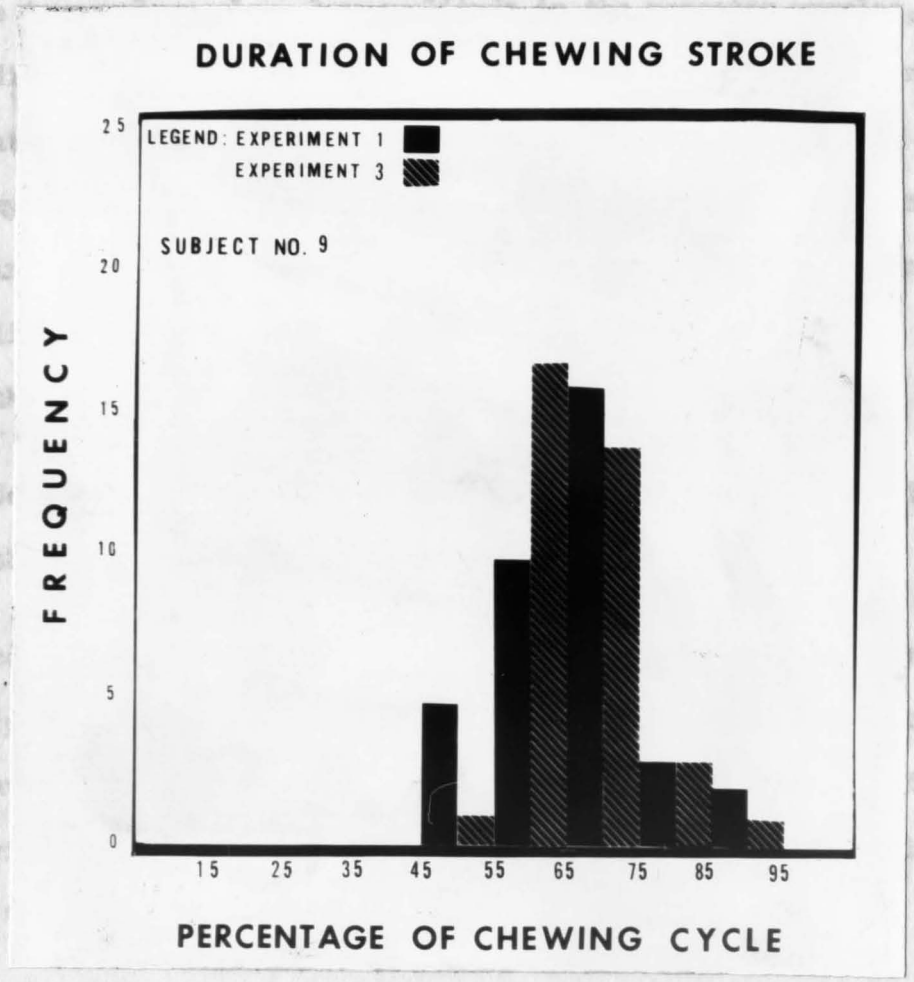
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	27	26	23	20	8	8	8	16	1	8
Exp. 3	31	31	30	30	8	11	11	15	2	8

Chi Square = 0.7162
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
2	Masseter first	3
0	Masseter and middle temporal first	0
0	Masseter and posterior temporal first	1
0	Middle temporal first	0
2	Middle and posterior temporal first	1
0	Posterior temporal first	1
5	All together (synchronous)	6
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 9
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #9 (C.R.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of multiburst activity, moderate amplitude in the temporal muscles, low amplitude in the masseter muscles, moderate duration, distinct noding, sustained low amplitude activity in the masseters, moderate rate of onset and ending, and minimal interim activity.

The myograms of Experiment #3 as compared to that of Experiment #1, showed slight increase in amplitude in all of the muscles studied, and no sustained low amplitude activity. All the other characteristics showed no apparent change in the myogram.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was .7462. Statistically, this means that there was no significant difference between experiments at the 95% confidence level. There was no appreciable difference in the behavior of the muscles studied in both experiments.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that the masseter muscle initiated the chewing stroke 2 out of 9 times; the middle and posterior tempo-

ral muscles initiated activity, 2 out of 9 times; and all muscles acted synchronously 5 out of 9 times. No marked changes were found in Experiment #3. *N.B.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 45-95% of the chewing cycle with the greatest frequency occurring at the 65-75 percentile. In Experiment #3 however, the duration of the chewing stroke ranged from 45-95% of the chewing cycle with the greatest frequency at the 55-75 percentile. No apparent change was seen in the behavioral pattern of the masseter and temporal muscles.

Summary and Conclusion:

Subject #9 displayed marked adaptability of the neuromuscular mechanism to orthodontic forces.

*N.B. - Here, 9 times instead of 12 because one exercise with 3 chewing strokes (Series B, Chew Right Vicks Cough Drop) was missing.

FINDINGS

Subject #10 (H.S.) Age: 14 years.

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between all the teeth.

THE BEHAVIOR OF THE MASSETER AND TEMPORAL MUSCLES

Subject #10 (H.S.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	2 to 3	2 to 4	0
Amplitude	xxx	xxx	0
Duration	x	x	0
Noding	x	xx	x
Sustained low amp.	x, Masseters	x, Masseters	0
Rate of onset	xx	xx	0
Rate of ending	xxx	xxx	0
Interim activity	x	x	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

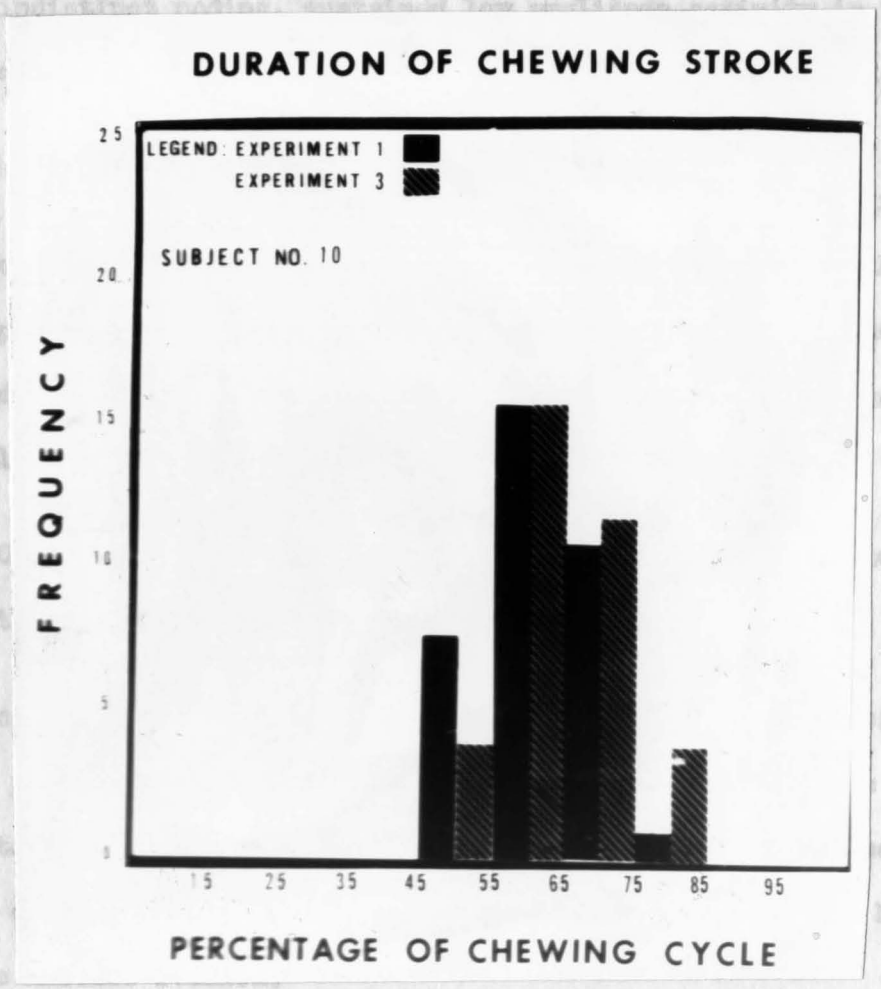
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	19	25	29	33	4	9	9	7	2	5
Exp. 3	26	33	28	31	6	12	12	19	9	12

Chi Square = 7.7257
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
2	Masseter first	0
1	Masseter and middle temporal first	2
0	Masseter and posterior temporal first	1
1	Middle temporal first	0
3	Middle and posterior temporal first	5
0	Posterior temporal first	0
5	All together (synchronous)	4
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 10
FREQUENCY
25
20
15
10
5
1
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #10 (H.S.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 2 to 3 bursts, high amplitude, short duration, indistinct noding, sustained low amplitude activity in the masseter muscle, moderate rate of onset, rapid rate of ending, and minimal interim activity.

The myograms of Experiment #3 compared with that in Experiment #1, showed some increase in noding. There was no appreciable change in the number of bursts, amplitude, duration, sustained low amplitude activity, and rate of onset and ending. This subject adapted to altered periodontal proprioception rather well.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 7.7257. Statistically, there was no significant difference between experiments at the 95% confidence level. There was hardly any change in the behavior pattern of the muscles studied.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that 2 out of 12 times the

masseter muscle acted first; 3 out of 12 times the middle and posterior temporal muscles acted first; and 5 out of 12 times the masseter, middle and posterior temporal muscles initiated the chewing stroke together. Thus, although synchrony was present to some extent, onset was varied. In Experiment #3, there was no appreciable change; onset was varied and combination of muscles initiated the chewing stroke.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 45-85% of the chewing cycle with the greatest frequency occurring at the 55-65 percentile. In Experiment #3, the range of the duration of the chewing stroke and the greatest frequency of occurence remained the same. This showed that the subject's ability to chew, was not affected by orthodontic forces after seven days.

Summary and Conclusion:

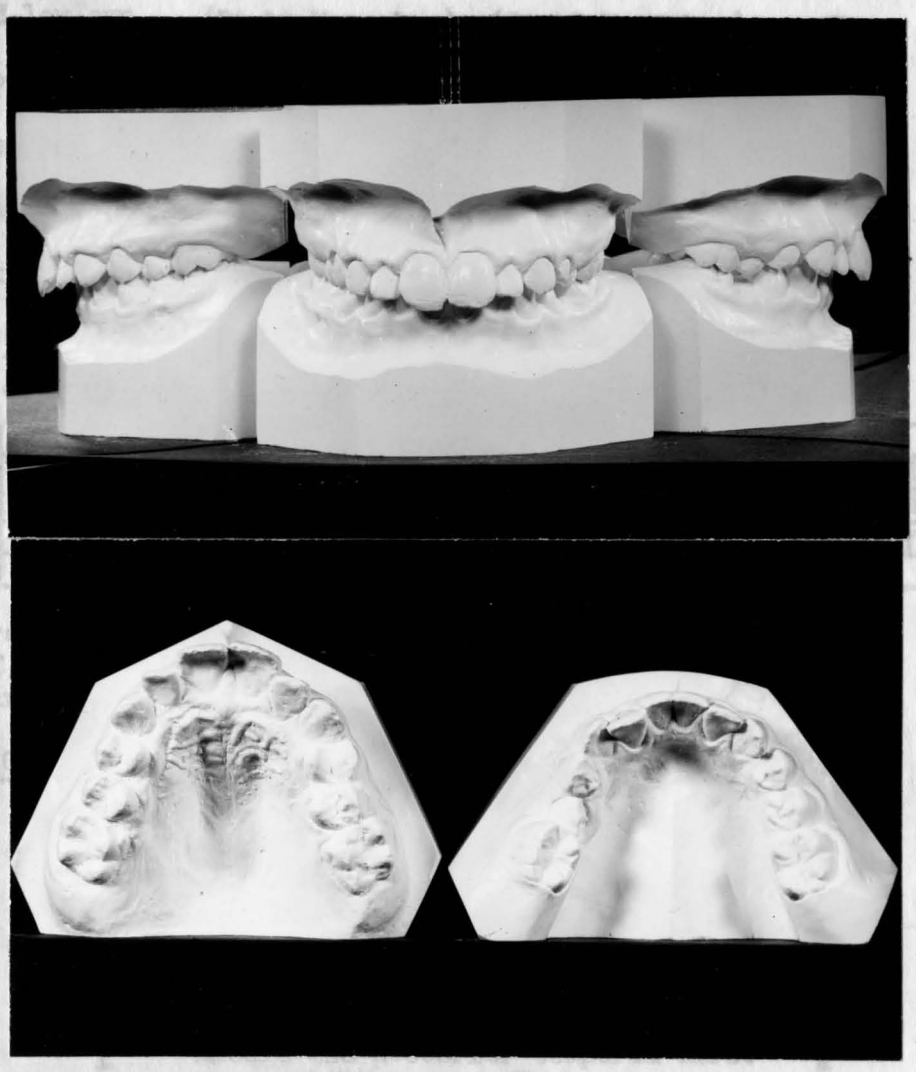
Subject #10 exhibited marked adaptability of the neuromuscular mechanism to orthodontic forces.

FINDINGS

Subject #11 (E.S.) Age: 12 years.

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between all the teeth.



Subject #11 (E.S.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	Multiple to "searching"	Multiple to "searching"	0
Amplitude	xx	x	x
Duration	(xxx, left side; xx, on the right side)	(xxx, left side; xx, on the right side)	0
Noding	xx	xxx	x
Sustained low amp.	(Right Masseter)	(Right Masseter)	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	xx	xx	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

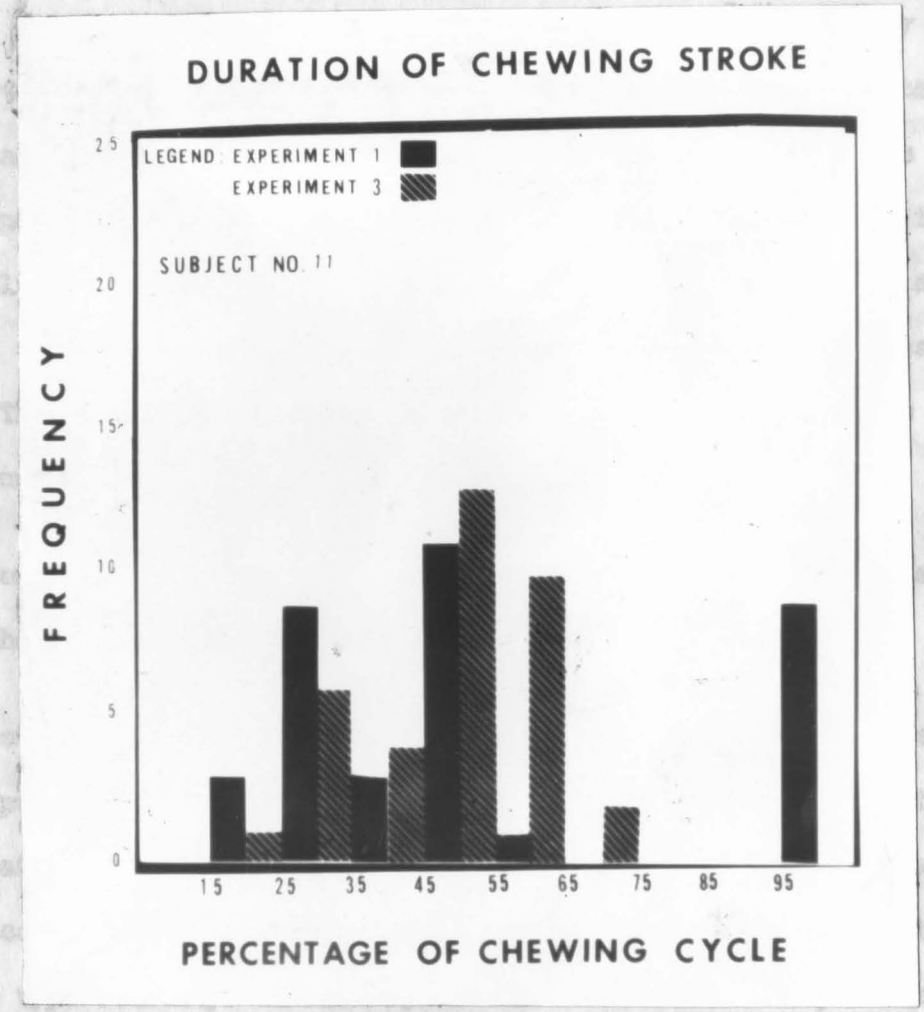
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	24	28	31	27	7	12	11	18	17	19
Exp. 3	33	33	24	27	11	10	10	19	3	6

Chi Square = 14.316
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
3	Masseter first	4
1	Masseter and middle temporal first	1
0	Masseter and posterior temporal first	2
0	Middle temporal first	1
1	Middle and posterior temporal first	2
0	Posterior temporal first	0
7	All together (synchronous)	2
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 11
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #11 (E.S.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of multiple to "searching" patterns, moderate amplitude, long duration in muscles on the left, to moderate on the right side, fairly distinct noding, sustained low amplitude activity in the right masseter muscle, moderate rate of onset and ending and moderate degree of interim activity. Thus, some degree of difficulty in chewing was noticed.

In Experiment #3, the most obvious changes that occurred were in the decreased amplitude and more distinct noding. Other qualities showed no apparent change. It stands to reason that as amplitude increased, noding became more distinct. The overall behavior of the masseter and temporal muscles remained apparently unchanged.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 14,316. Statistically, there was no significant difference between experiments at the 95% confidence level. Amplitude decrease was usually associated with "searching" type activity. This subject showed some difficulty in chewing through the Vicks Cough Drop.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The analysis of onset of activity in Experiment #1 showed that the masseter muscle acted first 3 out of 12 times; and all the muscles acted synchronously 7 out of 12 times. Experiment #3 on the other hand, showed that the onset of activity became less synchronous and more variable.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 25-*100% of the chewing cycle with the greatest frequency occurring at the 45-55 percentile. In Experiment #3, the duration of the chewing stroke ranged from 15-75% of the chewing cycle, with greatest frequency occurring at the 55-65 percentile. There was total *(100%) inability to chew in 9 out of 36 chewing attempts in Experiment #1. In Experiment #3 the subject displayed no 100% activity and the duration of the chewing cycle remained moderately long.

Summary and Conclusion:

Subject #11 showed remarkable recovery and adaptability to the changes in the neuromuscular mechanism.

FINDINGS

Subject #12 (J.S.) Age: 14 years.

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between all the teeth except in the unerupted lower right second premolar area.

Subject #12 (J.S.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	Multiple on the right side.	Multiple on the right side.	0
Amplitude	xx, right side; xxx, left side.	xx, right side; xxx, left side.	0
Duration	xx, right side; x, left side.	xx, right side; x, left side.	0
Noding	x, right side; xx, left side.	xx, both sides.	x
Sustained low amp.	0	0	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	(xxx, right Mass. and Temp; left x)	(Same as in Expt. #1)	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

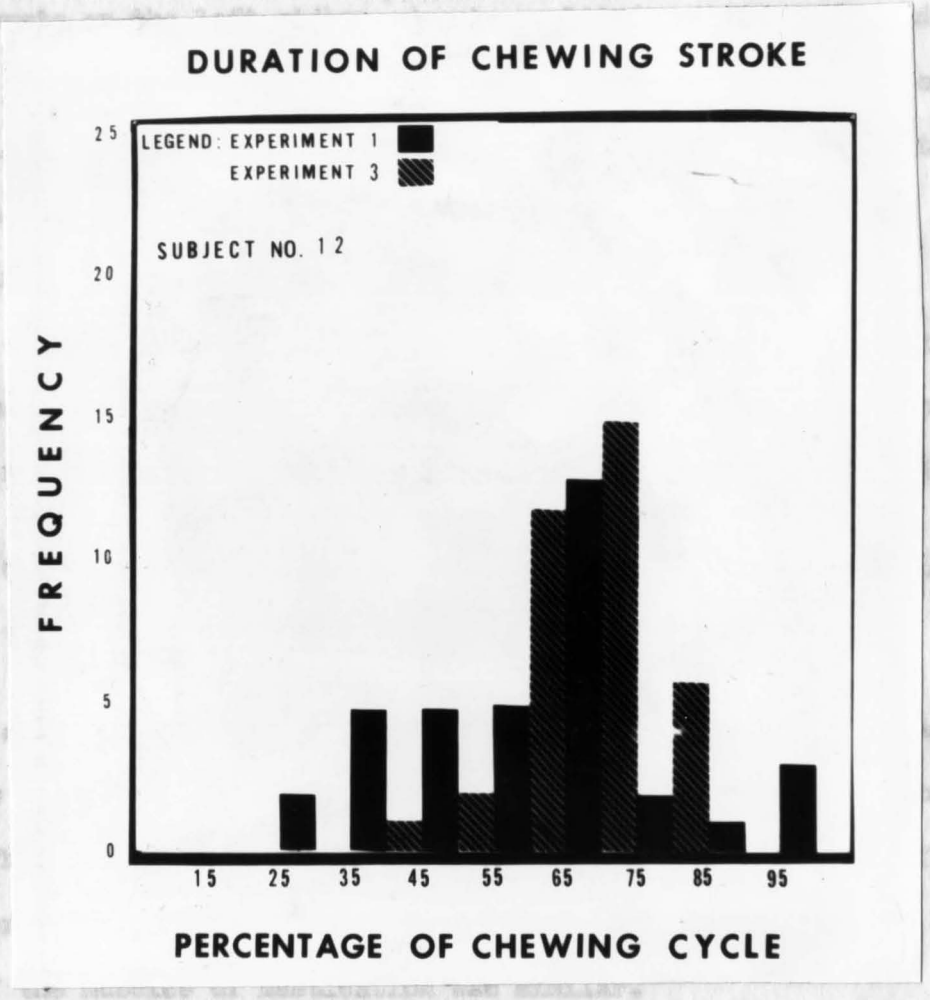
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	30	30	27	30	9	11	11	33	18	19
Exp. 3	30	29	26	28	6	9	8	23	15	15

Chi Square = 1.7857
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
5	Masseter first	4
1	Masseter and middle temporal first	0
1	Masseter and posterior temporal first	0
0	Middle temporal first	1
2	Middle and posterior temporal first	1
0	Posterior temporal first	2
3	All together (synchronous)	4
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 12
FREQUENCY
0
5
10
15
20
25
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #12 (J.S.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of multiburst activity on the right side and few bursts on the left side; moderate amplitude on the right and high amplitude on the left; moderate duration on the right and short duration on the left; indistinct noding on the right and fairly distinct noding on the left; no sustained amplitude activity; moderate rate of onset and ending; and maximal interim activity on the right side and minimal on the left.

The only change seen in Experiment #3 was a minor one. Noding became slightly more distinct while the other characteristics remained unchanged. There was no change in the functional behavior patterns of this subject.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 1.7857. This means that statistically, there was no significant difference between experiments at the 95% confidence level. This means that the behavioral pattern of the muscles of mastication was similar.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that the masseter muscle

initiated the activity 5 out of 12 times; the rest of the time onset was varied. In Experiment #3, there was no appreciable change in the onset of activity. It was still variable.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 25-100% of the chewing cycle with the greatest frequency occurring at the 65-75 percentile. In Experiment #3, the duration of the chewing stroke ranged from 35-85% of the chewing cycle with the greatest frequency occurring at the 65-75 percentile. No change was noted in the ability to chew. In fact, the duration of the chewing cycle became more consistent.

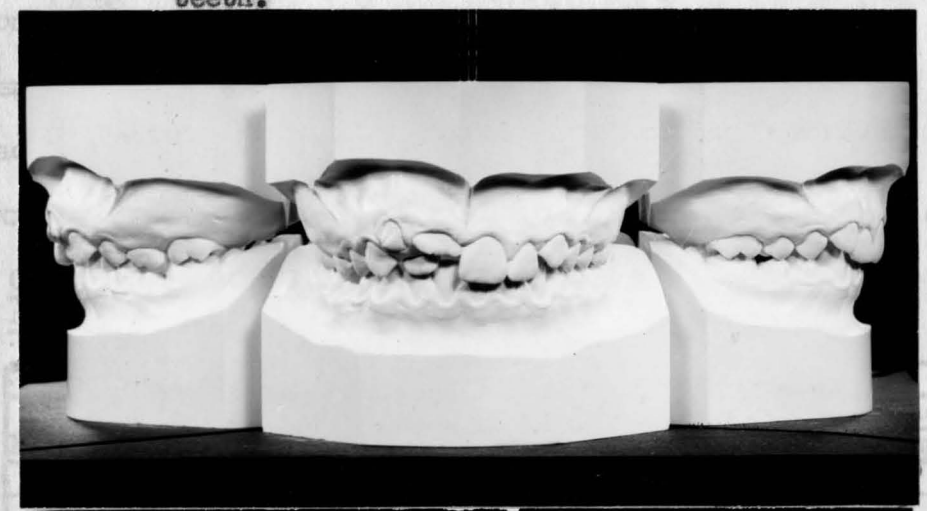
Summary and Conclusion:

There was a good measure of adaptability in Subject #12.

Subject #13 (A.N.) Age: 11 years.

Angle Classification of Malocclusion: Class II

Treatment: Separating wires were placed between all the teeth except the lower right second premolar and its adjacent teeth and the upper anterior teeth.



Subject #13 (A.S.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	2 to 3	2 to 5	0
Amplitude	xxx	xxx	0
Duration	xx	x	x
Noding	xx	xxx	x
Sustained low amp.	0	0	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	xxx	xx	x

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

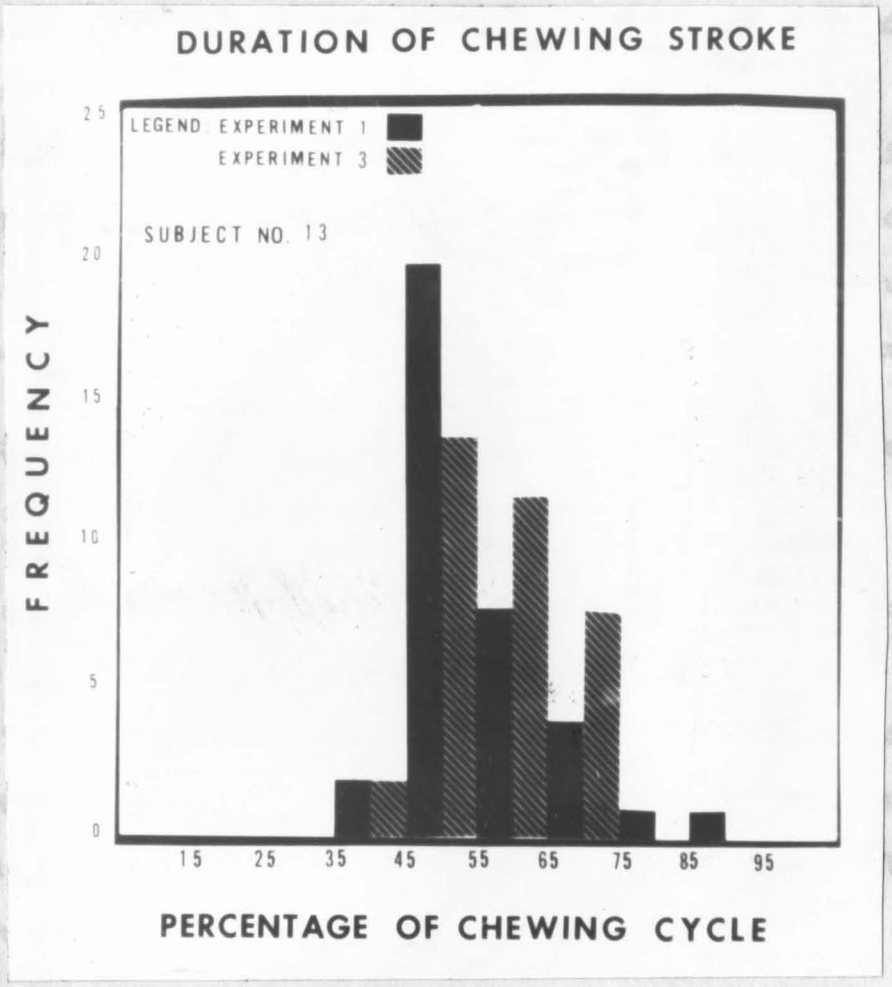
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	27	27	24	26	7	10	10	34	19	21
Exp. 3	34	33	30	27	12	11	12	15	5	8

Chi Square = 19.8222
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
6	Masseter first	2
1	Masseter and middle temporal first	1
1	Masseter and posterior temporal first	1
0	Middle temporal first	1
1	Middle and posterior temporal first	1
0	Posterior temporal first	0
3	All together (synchronous)	6
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 13
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #13 (A.S.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 2 to 3 bursts, high amplitude, moderate duration and fairly distinct noding, no sustained low amplitude activity, moderate rate of onset and ending, and maximal interim activity.

Myograms in Experiment #3 on the other hand, showed slight increase in number of bursts (2-5), shorter duration, more distinct noding and a marked decline in interim activity. All other characteristics remained unchanged. This subject showed no apprent difficulty in chewing a hard medium.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 19.8222. This means that statistically, there was a significant difference between experiments at the 95% confidence level. The difference could be attributed to a significant decrease in interim activity and a substantial increase in concurrence of noding, peaking, and onset of activity.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that the masseter muscle initiated the chewing stroke 6 out of 12 times. All muscles acted synchronously

3 out of 12 times. In Experiment #3, there was greater synchrony of onset but a variable onset of activity was still present. The onset of activity of this subject remained variable.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 35-95% of the chewing cycle with the greatest frequency occurring at the 45-55 percentile. In Experiment #3 however, the duration of the chewing stroke was from 35-75% of the chewing cycle with the greatest frequency of occurrence at the 45-55 percentile. No marked difference could be observed in the subject's ability to chew Vicks Cough drop.

Summary and Conclusion:

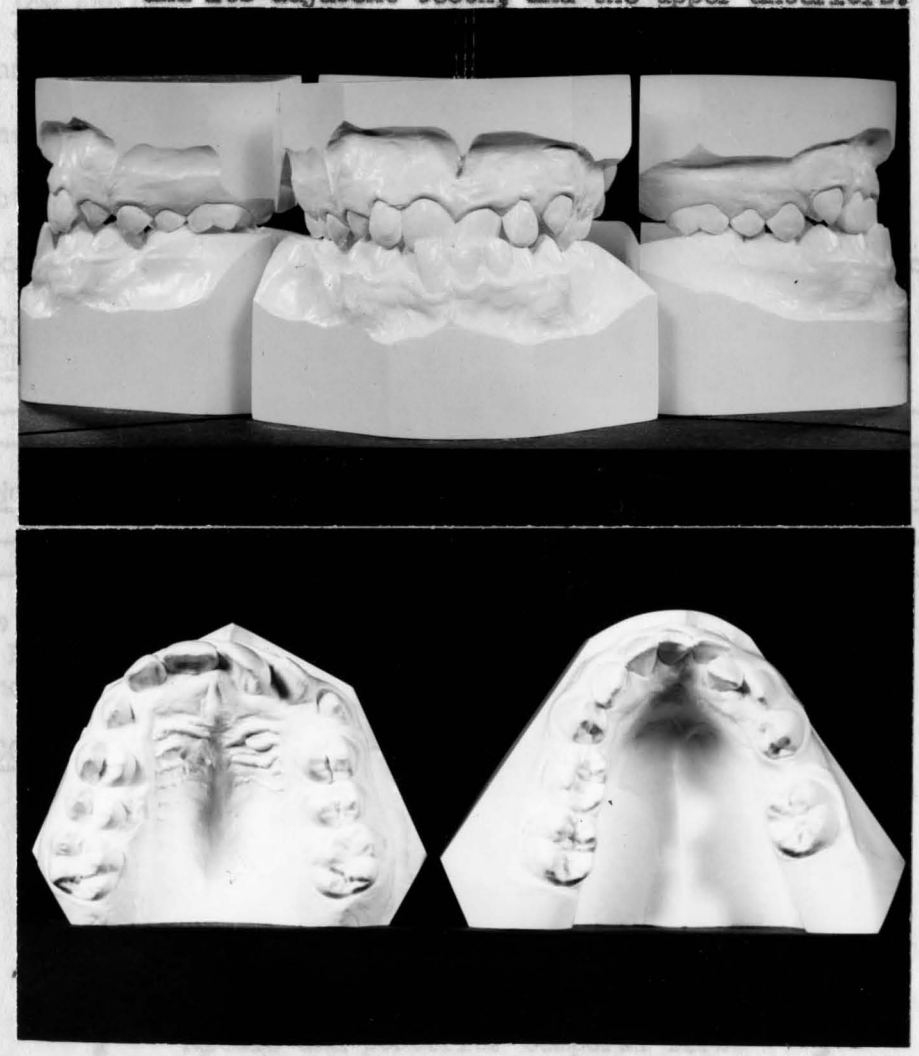
The neuromuscular pattern of behavior of subject #13 was minimally disturbed. This showed that some measure of adaptability was present after seven days.

FINDINGS

Subject #14 (D.T.) Age: 12 years.

Angle Classification of Malocclusion: Class I (Pseudo-Class III)

Treatment: Separating wires were placed between all the teeth except the lower right second premolar and its adjacent teeth, and the upper anteriors.



THE BEHAVIOR OF THE MASSETER AND TEMPORAL MUSCLES

Subject #14 (D.T.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	2 to 6	3 to 5	0
Amplitude	xx	xx	0
Duration	xx	xx	0
Noding	xxx	xxx	0
Sustained low amp.	(All Masseters; Rt. Mid. Temp.)	(Mid. Temp. and right Masseters)	x
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	x	xx	x

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

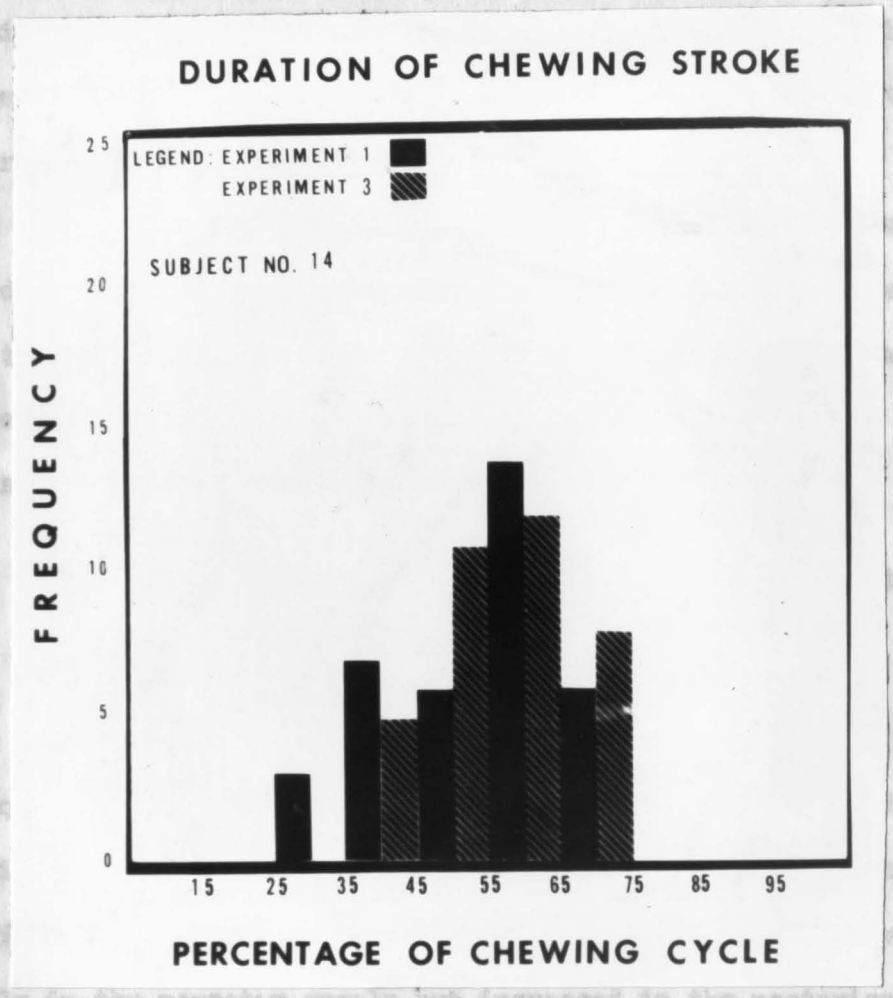
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	35	32	26	38	11	11	8	9	4	2
Exp. 3	29	31	28	27	6	10	12	15	4	4

Chi Square = 4.3217
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
6	Masseter first	3
0	Masseter and middle temporal first	0
1	Masseter and posterior temporal first	1
1	Middle temporal first	0
2	Middle and posterior temporal first	3
0	Posterior temporal first	1
2	All together (synchronous)	4
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 14
FREQUENCY
25
20
15
10
5
0
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #14 (D.T.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 2 to 6 bursts, moderate amplitude and duration, distinct noding, sustained low amplitude activity in the right middle temporal muscle, and in the first chewing stroke of masseter muscle; moderate rate of onset and ending, and minimal interim activity.

The myograms in Experiment #3 showed more uniformity in the number of bursts and increased interim activity. Sustained low amplitude activity was found in the middle temporal and right masseter muscles. There were no other observable changes in the myograms. Thus, the overall change in the behavior of the masseter and temporal muscles was practically nil.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 4.3217. Statistically, this means that there was no significant difference between experiments at the 95% confidence level. It was found that similarity of wave form decreased slightly in the masseter muscle but increased in the posterior temporal muscle; concurrence of noding increased, similarity of interim activity in the masseter muscle markedly increased, and the ending of the chewing stroke became less concurrent.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that the masseter muscle initiated the chewing stroke 6 out of 12 times; the rest of the time, onset was variable. In Experiment #3, although the onset was variable, there was a tendency toward synchronous behavior.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments (Quantitative Data)

The duration of the chewing strokes in Experiment #1 ranged from 25-75% of the chewing cycle with the greatest frequency occurring at the 55-65 percentile. In Experiment #3, however, the range was from 35-75% of the chewing cycle with the greatest frequency occurring at the 55-65 percentile. No change was noted in the central tendency. This means that the subject was consistent in the duration of his chewing stroke.

Summary and Conclusion:

No apparent disturbance in the neuromuscular behavior pattern was noted. Perhaps there was a measure of adaptability of the neuromuscular mechanism.

FINDINGS

Subject #15 (J.V.) Age: 14 years.

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between the posterior teeth only.

THE BEHAVIOR OF THE MASSETER AND TEMPORAL MUSCLES

Subject #15 (J.V)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	1 to 6	Multi-bursts; first chew, "searching".	xxx
Amplitude	xx	xx	0
Duration	xx	xxx	x
Noding	xx	xxx	x
Sustained low amp.	Posterior Temporals	Posterior Temporals	0
Rate of onset	xx	xx	0
Rate of ending	xx	xx	0
Interim activity	x	x	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

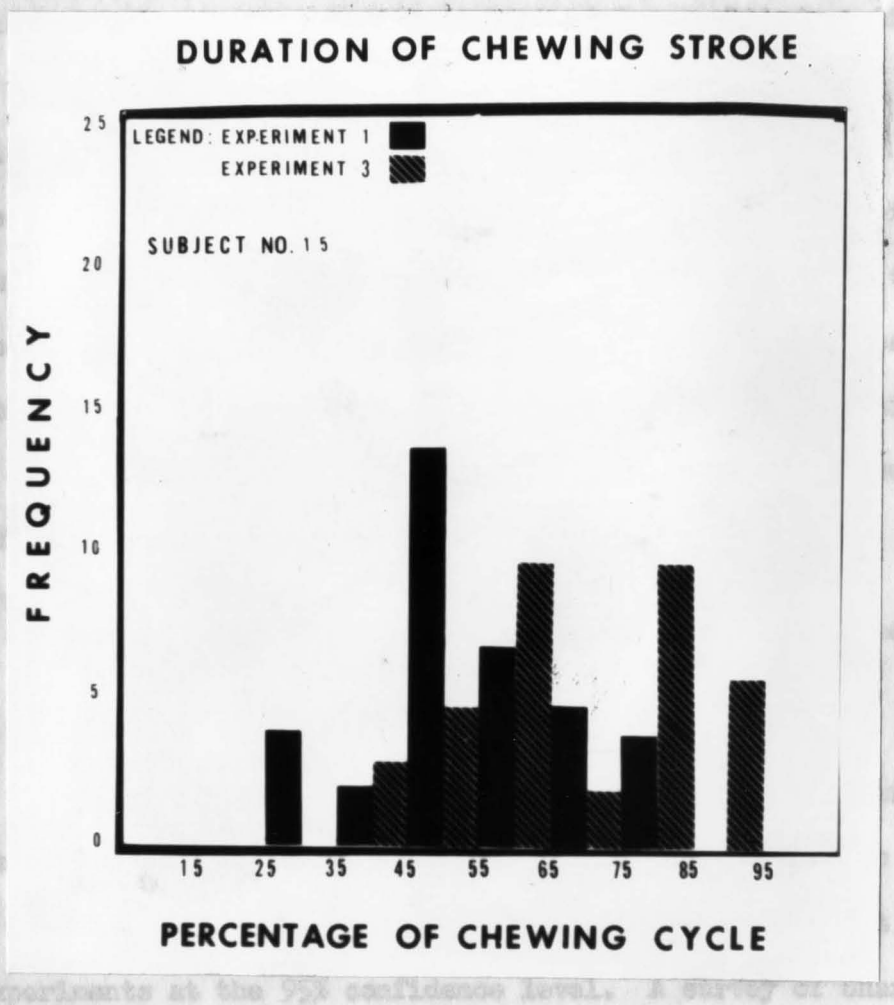
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	17	21	22	22	7	5	7	17	6	9
Exp. 3	30	30	23	26	10	12	12	6	3	5

Chi Square = 11.3456
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
3	Masseter first	3
0	Masseter and middle temporal first	1
0	Masseter and posterior temporal first	0
1	Middle temporal first	1
1	Middle and posterior temporal first	3
1	Posterior temporal first	0
6	All together (synchronous)	4
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 15
FREQUENCY
0
5
10
15
20
25
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #15 (J.V.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 1 to 6 bursts, moderate amplitude and duration, fairly distinct noding, sustained low amplitude activity in the posterior temporal muscle, moderate rate of onset and ending, and minimal interim activity.

Experiment #3 showed a substantial increase in the number of bursts. The first chewing stroke of all the exercises, exhibited "searching" type of pattern. Others showed multiburst activity. Noding became more apparent and duration of the myogram longer. Other characteristics showed no noticeable change. There was a marked change in the overall behavior pattern of masseter and temporal muscles. Adaptation was minimal.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiements #1 and #3 was put to the Chi-square test of significance. The value obtained was 11.3456. Statistically, this means that there was no significant difference between experiments at the 95% confidence level. A survey of Chart 2 showed that noding, and peaking became concurrent and that interim activity in the masseter muscle, less similar. This is another evidence of altered muscle behavior due to change in proprioception.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

Experiment #1 showed that the masseter muscle initiated the chewing stroke 3 out of 12 times, and along with the middle and posterior temporals (synchronously), 6 out of 12 times. In Experiment #3, the onset of activity became more variable with no set rule as to which muscle or muscles acted first in initiating the chewing stroke.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 25-85% of the chewing cycle with the greatest frequency occurring at the 45-55 percentile. In Experiment #3, the duration of the chewing stroke ranged from 35-95% of the chewing cycle with the greatest frequency occurring at the 65-85 percentile. This is additional evidence of neuromuscular disturbance. No positive adaptation was observed.

Summary and Conclusion:

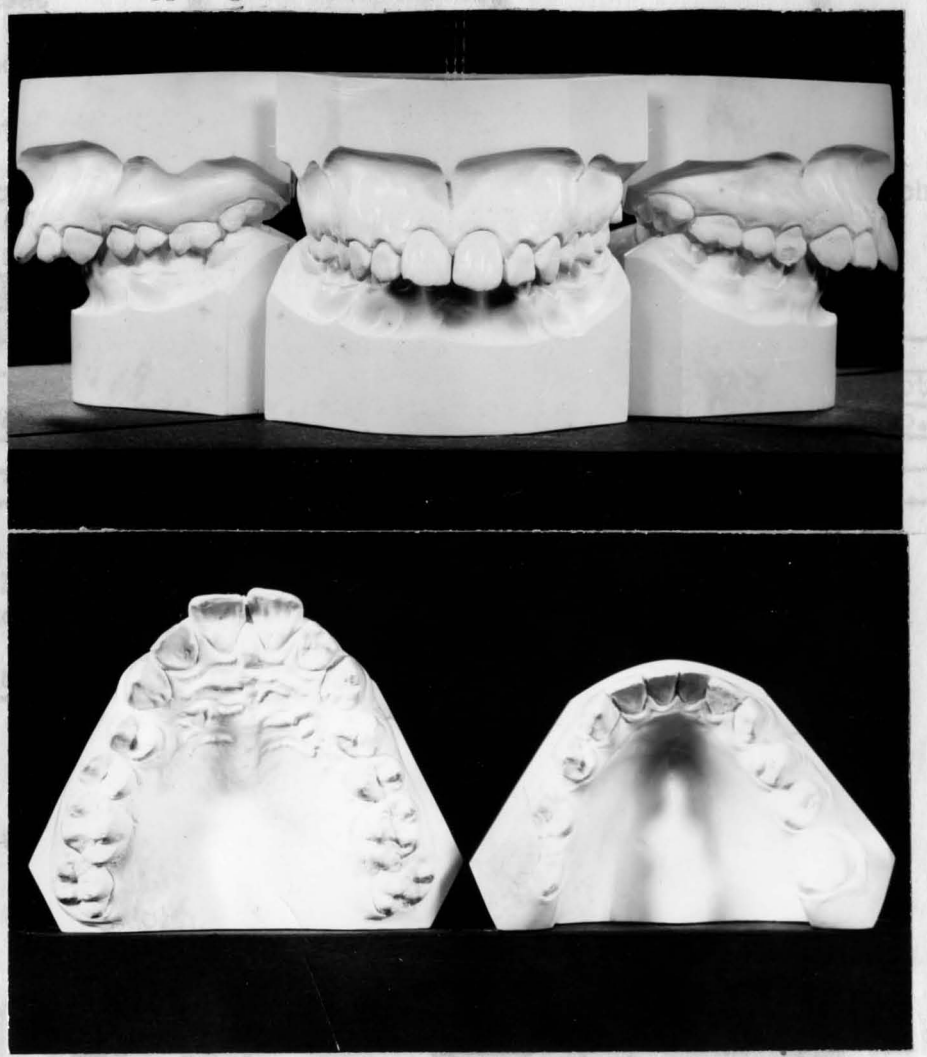
Subject #15 exhibited some measure of disturbance of the neuromuscular mechanism.

FINDINGS

Subject #16 (J.W.) Age: 12 years.

Angle Classification of Malocclusion: Class II, Division 1.

Treatment: Separating wires were placed between the lower left second premolar and first molar teeth; also between the lower anterior teeth and between the upper posterior teeth.



THE BEHAVIOR OF THE MASSETER AND TEMPORAL MUSCLES

Subject #16 (J.W.)

CHART 1. COMPARISON OF THE CHARACTERISTICS OF MYOGRAMS BETWEEN EXPERIMENTS

	Experiment 1	Experiment 3	Difference
Bursts	2 to 6	2 to 6	0
Amplitude	x	x	0
Duration	x	xx	x
Noding	x	xx	x
Sustained low amp.	All muscles	All muscles	0
Rate of onset	x	x	0
Rate of ending	x	x	0
Interim activity	x	x	0

Legend: xxx = maximum, xx = moderate, x = minimum, 0 = no obvious change

CHART 2. COMPARISON OF CONCURRENCE AND SIMILARITY OF MYOGRAMS BETWEEN EXPERIMENTS

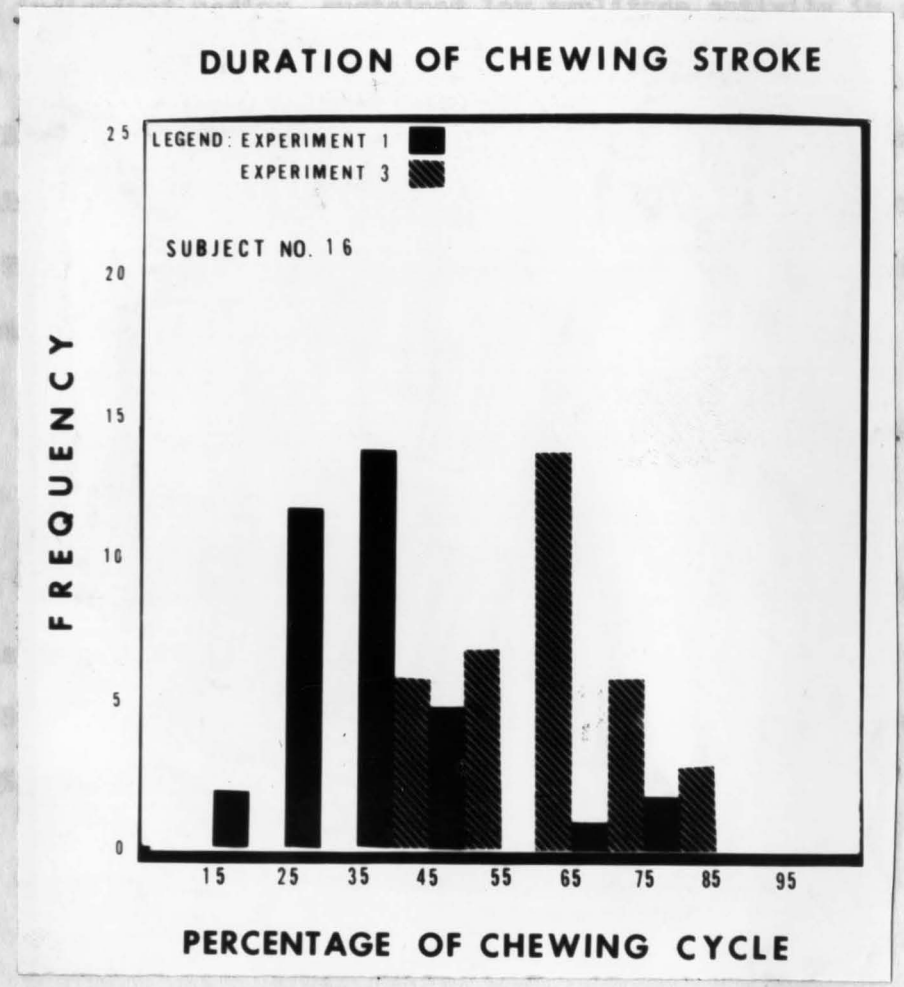
	Concurrence				Similarity					
					Form			Interim Activity		
	Nodes	Peaks	Onset	End	Mass.	M.Temp.	P.Temp.	Mass.	M.Temp.	P.Temp.
Exp. 1	25	22	25	25	11	11	7	25	12	14
Exp. 3	30	30	30	28	4	11	12	10	6	11

Chi Square = 6.6972
Degree of Freedon = 9.0
Significance level at .05 = 16.92

CHART 3. COMPARISON OF ONSET OF ACTIVITY BETWEEN EXPERIMENTS

MUSCLES

Exp. 1		Exp. 3
1	Masseter first	0
1	Masseter and middle temporal first	1
1	Masseter and posterior temporal first	0
0	Middle temporal first	0
3	Middle and posterior temporal first	5
3	Posterior temporal first	0
3	All together (synchronous)	6
12	Total number of chewing strokes	12


DURATION OF CHEWING STROKE
LEGEND: EXPERIMENT 1
EXPERIMENT 3
SUBJECT NO. 16
FREQUENCY
0
5
10
15
20
25
15
25
35
45
55
65
75
85
95
PERCENTAGE OF CHEWING CYCLE

FINDINGS - Subject #16 (J.W.)

Chart 1. Comparison of the Characteristics of the Myograms Between Experiments

Experiment #1 presented myograms of 2 to 6 bursts, low amplitude, short duration, indistinct noding, sustained low amplitude activity in all muscles, slow rate of onset and ending, and minimal interim activity.

In Experiment #3, there was a slight increase in duration and slightly more distinct noding. All other characteristics exhibited no appreciable change. This subject thus showed a moderate degree of change in the neuromuscular pattern behavior.

Chart 2. Comparison of Concurrence and Similarity of the Characteristics of the Myogram Between Experiments.

The concurrence and similarity of the myograms between Experiments #1 and #3 was put to the Chi-square test of significance. The value obtained was 6.6972. Statistically, there was no significant difference between experiments at the 96% confidence level.

Chart 3. Comparison of Onset of Activity of the Masseter, Middle Temporal, and Posterior Temporal Muscles Between Experiments.

The onset of activity in Experiment #1 showed that posterior temporal muscle was outstanding in initiating the chewing stroke (3 out of 12 times by itself) and together with other muscles (7 out of 12 times). In Experiment #3,

no single muscle initiated the chewing stroke, but all of them acted synchronously with other muscles.

Bar Graph: Comparison of the Duration of the Chewing Strokes Between Experiments. (Quantitative Data)

The duration of the chewing stroke in Experiment #1 ranged from 15-85% of the chewing cycle with the greatest frequency occurring at the 35-45 percentile. In Experiment #3, however, the duration of the chewing stroke ranged from 35-85% of the chewing stroke and the frequency of occurrence at 55-65 percentile. There was a positive change in the behavior pattern of the masseter, middle temporal, and posterior temporal muscles.

Summary and Conclusion:

A moderate degree of adaptation was observed in the neuromuscular pattern of behavior of Subject #16.

CHAPTER IV

DISCUSSION

A. General Considerations

This study is Part II of a longitudinal electromyographic investigation designed to study the effects of an orthodontic treatment using light resilient wires and light force elastics upon the behavior of the masticatory muscles. The purpose of the present investigation was to study the effect of altered sensory periodontal nerve stimulation due to placement of separating wires between the teeth, and the subsequent effect upon the behavior of the masseter and temporal muscles. In order to accomplish this aim, the electromyograph was employed and the electrical discharges from these muscles were recorded.

Sixteen orthodontic subjects presenting varying malocclusions constituted the heterogeneous group from which the electromyographic findings were derived. The findings of each subject was compared to his original pretreatment record (Experiment #1).

All subjects were free from any apparent temporomandibular disturbances or muscle spasms during the course of treatment. Vicks cough drops were selected as the chewing medium. While the subjects chewed on a cough drop according to instructions, ipsilateral myograms were recorded of the masseter, middle and posterior temporal muscles.

The placement of separating wires between the teeth creates a force which tends to move them in opposite directions. A force exerted on the teeth

stretches the periodontal ligament. The degree of stretch depends on the direction, magnitude and duration of the force acting over the period of activation. The separating wires usually act rapidly over a short distance and for a short span of time. Thus, the occlusal relationship of the teeth may be changed, and it is conceivable that this may alter muscular behavior. It is known that changes engendered in the periodontal ligament will affect the afferent nerve endings in periodontium. These afferent nerve endings are proprioceptive, pain and pressure end organs. These have been described histologically by Dependorf (1913), Lewinsky and Stewart (1927), Kadanoff (1936), Van der Sprenkel (1936), and Rapp (1957).

The keen sense of discrimination of the proprioceptive fibers to varying degrees of stimuli, have been experienced by all. A high spot on an inlay or amalgam restoration is easily discerned. The role of these proprioceptors in the functional movement and reflex movements of the mandible was shown by Sherrington (1917) and Corbin and Harrison (1940).

Hypothesizing then: Is it not logical to assume that the placement of separating wires between the teeth to gain space for fashioning and cementation of orthodontic bands, causes a primary alteration of periodontal proprioception and thus, secondarily affect the behavior of the neuromuscular mechanism? For an answer to this question, let us analyze and discuss the findings of this investigation.

B. Interpretation and Evaluation of the Findings.

The myograms of the masseter, middle and posterior temporal muscles were

analyzed in the following manner:

1) The myograms were grossly evaluated for their overall characteristics, namely the number of bursts, amplitude, duration, noding, sustained low amplitude activity, rate of onset and end of activity, and interim activity.

2) The concurrence and similarity of these characteristics were studied and the results put to a Chi-Square test of significance.

3) The onset of activity of the masseter and temporal muscles were evaluated for frequency of onset; that is, by determining the number of times one muscle or a combination of muscles acted to initiate the chewing stroke.

4) Duration of the chewing stroke was evaluated according to percentage of the chewing cycle. The resulting percentage values were plotted as histograms and converted to bar graphs.

Findings Based on the Characteristics of the Myograms

The characteristics of the myogram were compared in Experiment #1 and Experiment #3. The number of bursts in the myogram in the latter experiment increased slightly in the minority of the subjects, (5 out of 16) while the remainder showed no change (11 out of 16). Those that showed no evidence of change in number of bursts, displayed one to six bursts patterns. Four subjects in the minority group showed multi-burst patterns while only one showed the "searching" pattern mentioned by Perry (1955). It is obvious then that the majority of the subjects exhibited no appreciable change in the number of

bursts in the myograms of the temporal and masseter muscles.

There was no apparent change in the duration and amplitude of the myogram in three-fourths of the subjects. The remainder showed only a slight increase. There was no apparent change in all of the subjects as far as sustained low amplitude activity was concerned. The rate of onset and end of activity and the interim activity (myotatic reflex?) showed no appreciable difference in all of the subjects. Low amplitude transitory activity bordered by high amplitude activity was called "noding". Since no low sustained low level activity was found in the majority of the subjects, noding was distinct as it depended on high amplitude activity.

In the general evaluation of the muscular activity of all the subjects, there was no apparent changes in three-fourths of the subjects studied for characteristics of the myogram. This may be attributed to nature's phenomenon of adaptation which helps us to re-establish homeostasis within the stomatognathic system. Jarabak (1954) described this phenomenon of adaptability of the temporal and masseter muscles in subjects with excessive interocclusal space when orthodontic splints were worn.

The present findings reveal that any change that did occur as the result of placing separating wires between the teeth (Widen Part I), disappeared by the seventh day in three-fourths of the subjects. It is logical to assume that 1) the mobility of the teeth increased; 2) there was a widening of the periodontal ligament space and lengthening of the periodontal ligament; and 3) adaptation and initial repair of the damaged tissues may have occurred in seven days. It is conceivable that trauma to the periodontium was minimal and

well within the tolerance of the individual's pain threshold, for none of the subjects complained of pain during the performance of the chewing exercise. This phenomenon of adaptation was described by Wentz, Jarabak, and Orban (1958) in their histological experiments with monkeys. They found that:

> ...traumatic tissue changes of the early experiment (due to "jiggling"), completely disappeared within three months and the periodontium appeared normal except for the lengthened periodontal ligament. The widening of the periodontal space and lengthening of the periodontal ligament may be considered as a functional adaptation of the tissues due to changes in the functional requirements.

Aside from specie difference, the only dissimilarity between the present investigation and the aforementioned, was possibly in the magnitude, duration, direction, and distance of the induced "jiggling" force. The effect on the periodontium however, was similar.

Comparison of Concurrence and Similarity of the Characteristics of the Myogram between Experiments.

Statistically, there was no significant difference in the behavioral pattern of the myogram in 14 out of 16 subjects. Two of the remaining subjects showed marked dissimilarity in interim activity which means that there was a change in the behavioral pattern of the masseter and temporal muscles. The Chi-square difference was attributed to a marked reduction in interim activity between the chewing strokes of the muscles studied, no significance was placed on the difference found in these subjects (#2 and 13). Other characteristics were found to be just as similar. The decrease in interim activity was believed to be due to psychogenic factors such as lessened apprehension, famili-

arity with the experiments, practice effects, etc. Many of the subjects therefore, showed almost total absence of interim activity between the chewing strokes. Interim activity was readily identified with the use of sonograms. (See Figure 3)

Comparison of Onset of Activity of the Masseter and Temporal Muscles between Experiments.

The onset of activity of the muscles studied though varied to some degree, was more synchronous in Experiment #1 than in #3. In Experiment #1, one-half of the subjects (8 out of 16) showed that the masseter muscle was first to initiate the chewing stroke. The remainder of the subjects showed some degree of variability in the onset of the chewing stroke in the temporal and masseter muscles. In Experiment #3, two subjects showed that the masseter was first to initiate the chewing activity. The remainder of the time, the masseter muscles responded variably and initiated the chewing stroke in combination with or synchronously with the middle and posterior temporal muscles. Harris and Perry (1954) showed in their study of Class II malocclusions that the masseter was early and constant in its onset of chewing activity. However, the present experiment (#3) showed that there was no set rule as to what muscle would initiate the activity of the chewing stroke at any given time, just as Jarabak stated in 1954. He said:

> One cannot ascribe a true function to any given muscle for any given time. The function of the muscle is generally predetermined by the status quo of the body in space.

This statement may be readily applied to logically describe the initiation of

the chewing stroke.

Comparison of the Duration of the Chewing Stroke between Experiments.

The duration of the chewing stroke was expressed quantitatively as a percentage of the chewing cycle. In Experiment #3, the range of the duration of the chewing stroke decreased or remained the same in all subjects except one (15 out of 16). This may be explained on the basis of accommodation. None of the subjects exhibited 100% duration of the chewing stroke in Experiment #3, whereas, two subjects (#11 and #12) displayed this phenomenon in Experiment #1. The change may be due to familiarity with the chewing medium and lessened apprehension on the part of the subjects. Only one subject (#6) showed increase in the range of duration of the chewing stroke. Perhaps pain was a factor to be considered although the patient did not admit it, which influenced this finding. This was considered to be insignificant since it occurred in one out of thirty-six myograms studied. The measure of occurrence of central tendency remained unchanged in this one subject. Only one subject showed any sign of difficulty in mastication. (See Graph on Subject #6).

The frequency of occurrence (a measure of central tendency) remained unaltered in the majority of the subjects (9 out of 16). This means that there was neither a shift to the left (decrease in the duration of the chewing stroke) as seen in the duration graphs. Two subjects (#2 and #9) showed a decrease in duration of the chewing stroke, which means that no difficulty was encountered in chewing through the Vicks cough drop. The remainder of the subjects (5 out of 16) showed some increase in the central tendency (See Graphs for Subjects

#1, 3, 7, 15, and #16). This can be interpreted to mean that some difficulty existed in chewing through the hard medium. Overall however, more than one-half of the subjects showed no appreciable change in their ability to masticate. This again may be explained on the basis of adaptability of the neuromuscular mechanism and it followed according to Sicher (1949) that:

> Loss of teeth or changes in their position are followed by a rather rapid adaptation of movements in order to achieve maximum effect with minimum effort; that is with the least waste of muscular energy.

CHAPTER V

SUMMARY AND CONCLUSIONS

A. Summary

This investigation was the second part of a logitudinal electromyographic study comparing the behavior patterns of the temporal and masseter muscles before, during, and after orthodontic treatment using light forces. The general pattern of behavior of the temporal and masseter muscles was analysed and studied by means of myograms. The pretreatment (Experiment #1) records and the records taken seven days after placement of separating wires between the teeth (Experiment #3), were compared. Vicks cough drop was used to test the ability of the subjects to chew and the myograms were recorded ipsilaterally.

The behavior of the masseter and temporal muscles mediated by altered periodontal proprioception due to placement of separating wires, was reported in Part I of this longitudinal study (Widen, 1960). The remarkable adaptability of the muscles of mastication to changes in the periodontium and the rapid re-establishment of homeostasis of the neuromuscular mechanism was discussed.

The results of this study were based on the interpretation and evaluation of the characteristics of the myogram. Wherever possible, the findings were tested statistically for differences.

B. Conclusions

1. Any changes in the behavior of the temporal and masseter muscles that did occur (Widen, Part I, 1960), as a result of placing separating wires between the teeth, disappeared by the seventh day in majority (12 out of 16) of the experimental subjects.

2. The variability of onset of activity in the masseter and temporal muscles showed that no set rule can be found as to which muscle will initiate the chewing activity.

3. There was no statistically significant difference in the similarity of the characteristics of the myogram in majority (14 out of 16) of the subjects.

4. The ability to chew a hard medium (Vicks cough drop) was unaffected in over one-half (9 out of 16) of the subjects.

5. The disappearance of changes noted in the first part (Widen, 1960) of the study, could be attributed in part to the adaptation of the neuromuscular mechanism.

6. The sonograms (sound tracings), were an invaluable aid in identifying and isolating certain characteristics of the myogram which were difficult to distinguish. For example, the onset (beginning of the chewing stroke); end (the termination of the chewing stroke); and interim activity (myotatic reflex?) which is that activity present between chewing strokes.

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APPROVAL SHEET

The thesis submitted by Dr. Steve Noboru Asahino has been read and approved by four members of the Departments of Anatomy and Oral Anatomy.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

5-18-66
Date

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Signature of Adviser